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August 1961

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Front Cover: Cessna's latest series production model, the five-seat *Skyknight* executive aircraft. The first aircraft, equipped with two Lycoming TISO-470-B 260 h.p. supercharged engines, are just being delivered.

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Editorial Staff and Translators
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Business Managers
J. VOLLENWEIDER (Administration) P. RUSSAK (Advertising)

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Agents:

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Interavia Austria Postfach 192, Vienna I./1
Interavia Belgium 149, avenue des Statuaires, Brussels 18
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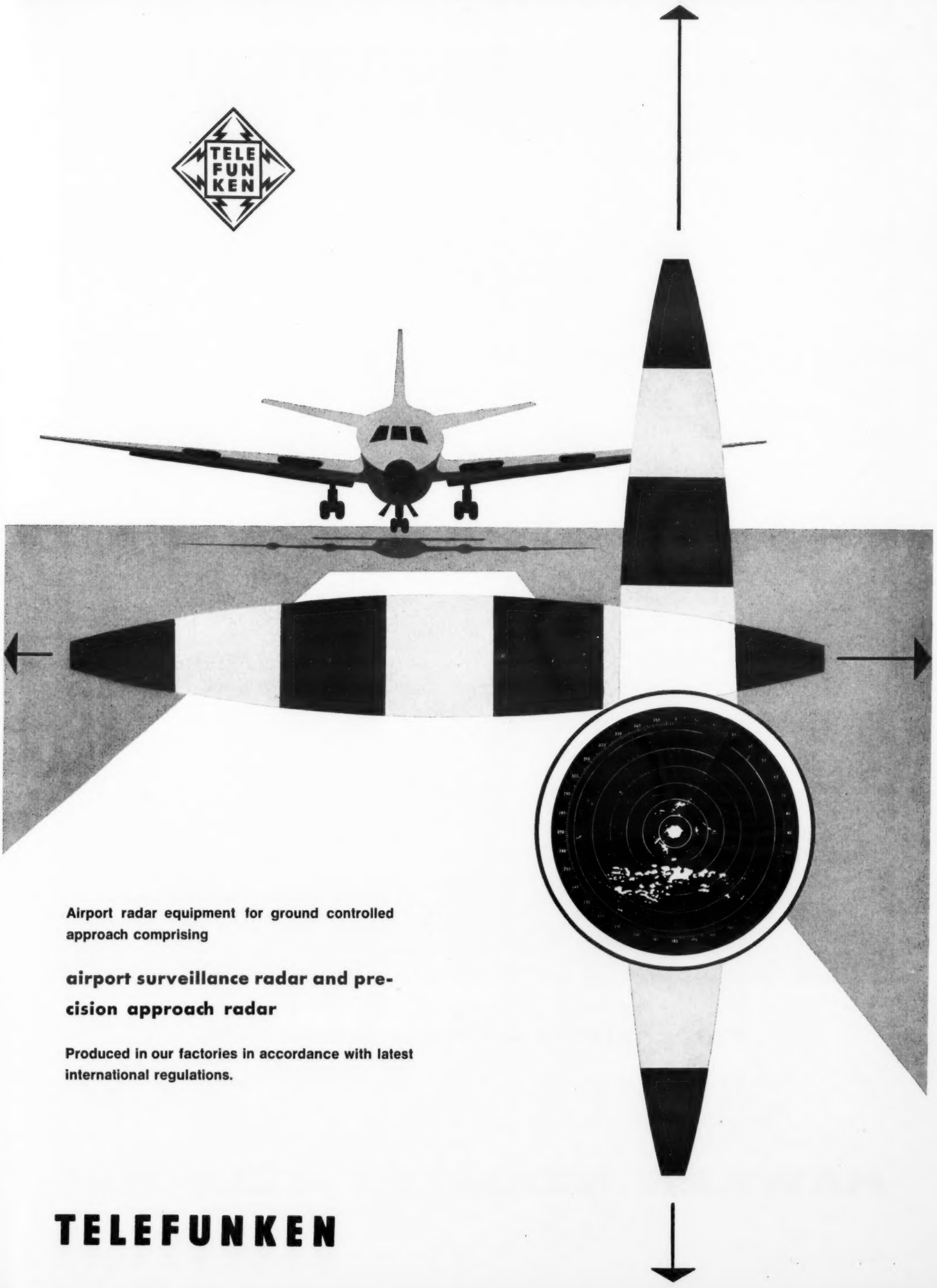

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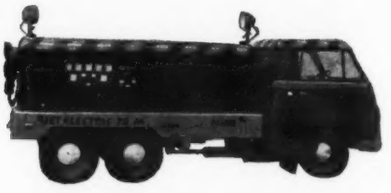

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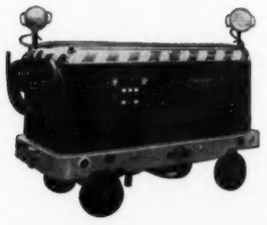

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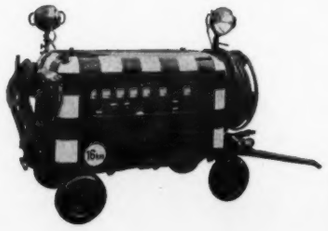

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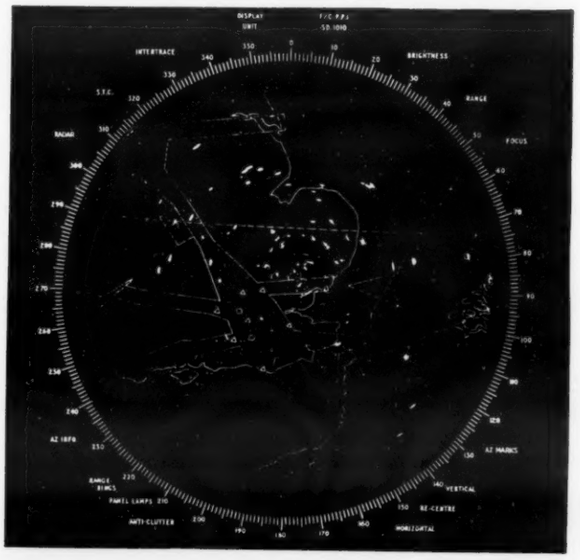

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INTERAVIA AIR LETTER reports...*

Air Transportation

North Atlantic traffic is showing signs of improvement, but capacity will considerably exceed traffic on the route this summer. U.S. travellers are postponing their vacations or have switched from Europe to the Far East and South America, and it is unlikely that the heavy traffic forecast at the beginning of this year will in fact materialize before the end of the peak season.

A survey of Atlantic carriers' New York offices towards the end of July produced the following picture:

● **PanAm** expects a 16% increase for the season with July traffic up 19% eastbound and 5% westbound. August bookings were down, but a 10% rise is expected due to late booking tendency. A 50% increase in capacity and increased competition are producing low load factors.

● **TWA**–traffic down 25% for first five months, but a July pick-up had been noted. Traffic for the season will probably be down 15% and load factors low, but a late improvement is expected.

● **BOAC**–capacity is up 42% but traffic up only 10%, partly due to late bookings and strike actions.

● **Alitalia**–traffic up 55.8% for first 17 days of July with load factors at 76.3% against 95% last year. Capacity is up 100% and August bookings show a 20% increase on 1960, but should run even higher.

● **Lufthansa**–traffic has been disappointing but late bookings are expected to improve the situation. July load factor was running at 71.5% against 96.6% last year but with 5,000 additional seats on offer.

● **Air France**–traffic in July was up 30%. Capacity had been increased 60% and load factors were about 10% down on last year. August bookings were up 20% but were expected to go higher with late bookings.

●

North Atlantic carriers met in London for informal talks July 18th-21st to consider lower group travel rates and extension of the excursion rate through the summer season. No agreement was reached but this was anticipated in view of widely diverging views. Carriers may continue with informal meetings over the next few months before making a further attempt at agreement towards the end of the year.

Eastern Air Lines raised frequency on its highly-successful Boston-New York no-frills shuttle service from eight to sixteen flights a day in each direction, effective August 1st. Flights (no reservations—seat guaranteed) depart Boston and New York every hour in the period 07:00 to 22:00 each weekday.

●

U.S. carriers now interested in possible merger with Northeast Airlines include Delta, Eastern, National, Northwest, Pan-Am, Riddle, TWA and Trans-Caribbean. CAB is promoting the merger, and Eastern may get the nod to go ahead with proposals. American, TWA, and United are in any case probably out of the running due to their present size.

CAB hearings on Northeast's New York-Florida route renewal application are expected in December this year, and final decision on a possible merger may not be forthcoming until well into 1962.

●

Lufthansa route development plans are mainly concerned with new overseas services. The carrier wants to introduce new service to the northern states of South American (Venezuela, Colombia, Ecuador, and Peru) and also plans a West African coastal route and a South African service. The Far East route network will also be developed with additional legs breaking off from existing routes. Plans will require prior negotiations with all the countries concerned.

●

Sabena's deficit for 1960 is reported at 131,735,947 Belgian francs ($2.6m), as anticipated. The deficit, to be covered by a Belgian Government advance, is 65 million francs ($1.3 m) lower than the figure reported for 1959. Results were heavily affected by the Congo airlift operation, which took all Sabena's Brussels-based long-haul aircraft and the entire Congo-based fleet out of normal service for three weeks in July. Profits were also affected by appropriation of 75 million francs ($1.5m) for extra depreciation on piston-engine aircraft following the introduction of Boeing 707 and *Caravelle VI* jets into service. Sabena has ordered two more Boeing 707-329s and has an option on a seventh.

●

Spanish flag carrier Iberia will take delivery of four *Caravelle VIRs* in January 1962 (one), March (one) and April (two). Iberia's New York office says additional DC-8 orders are planned for intercontinental routes.

●

Madagascar's new national airline, to be formed in association with Air France and TAI, will have the name *Madaira*, according to reports from Paris. Formation will be completed by October 14th and the company will have sole rights for operation of the domestic network. On international routes, at least one DC-7 flight a week Tananarive-Djibuti-Marseilles-Paris is planned. Madagascar is expected to become a member of ICAO on January 1st, 1962. A 1,500 million CFA francs development programme (approximately $6m) is planned to bring Tananarive-Ivanto Airport up to international operations standard.

●

Ethiopia is to receive two U.S. Government loans totalling $23,350,000 for aviation projects, according to the Development Loan Fund. A sum of $3.1 million will help finance procurement of maintenance and overhaul equipment and spare parts to permit Ethiopian Airlines to handle overhaul of the two Boeing 720Bs now on order. Procurement will be mainly in the U.S. with a small portion financing local currency costs. A further $20,250,000 will be used for construction or improvements at four major and 22 smaller domestic airports. Plans include a new airport at Addis-Ababa and expansion of existing facilities at Asmara, Dire Dawa, and Jimma.

●

TEAL's application for roundtrip scheduled and non-scheduled services from New Zealand via the Fiji Islands to American Samoa and on to the Cook Islands and Society Islands appears to be receiving quick action from the U.S. Government. CAB started hearings in July and no delays are expected. If granted in full, TEAL will also be able to operate off-route charter services into and out of American Samoa (currently operated on the temporary six-month permit issued last March). TEAL has not applied for a permit to operate to the United States, but the current New Zealand-U.S. agreement permits a New Zealand carrier to fly to San Francisco and on to Vancouver. To date no carrier has expressed interest in serving these points, largely because of a lack of equipment.

Industry

Sud-Aviation's Caravelle sales are slowing down, according to a statement by Defence Minister Pierre Messmer to the National Assembly in July. Orders and options placed to date cover about 140 of the initial production run of 150 *Caravelles*. France's Comité National pour l'Expansion de l'Industrie Aéronautique has recommended production of a further batch of 50 up to a total of 200 aircraft, and has said that there should be no question of Air France purchasing competitive aircraft of foreign manufacture. With the exception of United Air Lines' order for 20 *Caravelles* (plus options on another 20), American orders have fallen below Sud-Aviation's expectations and no upswing appears likely before 1962.

Sud-Aviation's 1960 report showed 66.6% of activity centred around the *Caravelle* programme. Production will continue at four aircraft a month until 1962 but, on the basis of current orders, will run down at the beginning of 1963. Helicopter production accounted for 14.6 % of total activity with *Alouette II* production now running at 16 aircraft a month, and continuing until September 1962. Five Sikorsky S-58s are being rolled out each month and production of a batch of 50 *Alouette IIIs* has been launched. Military aircraft accounted for 9.5% of activity in 1960, with *Fennec* modifications of T-28s replacing *Vautour* production, which was phased out in July 1960. *Fennecs* are being completed at the rate of ten aircraft a month.

* Interavia Air Letter is a daily international news digest published in English, French ("Courrier Aérien"), and German ("Luft-Post"). All rights reserved.

French Transport Minister Robert Buron has suggested to British Aviation Minister Peter Thorneycroft that talks on a possible collaboration in development of a supersonic airliner should be held as soon as possible. Industry-level discussions were held between Sir George Edwards of BAC and Georges Héreil of Sud-Aviation in June, when the two companies agreed to explore the ground for future general cooperation. Sud-Aviation is pushing ahead with plans for a 1,400 m.p.h. supersonic *Super Caravelle* in collaboration with Marcel Dassault, and this programme will get French Government financial support. In the U.K., British Aircraft Corporation has a supersonic study contract from the Ministry of Aviation and a report should be submitted to the Minister within the next few months.

●

British industry received a big boost in June when both Sweden and Switzerland selected the Bristol-Ferranti *Bloodhound Mk.II* surface-to-air weapons system. Total value of the two orders (Sweden's firm, but the Swiss to be approved by Parliament) will be well over £50 million ($140m). Bristol Aircraft negotiated both sales in the face of very strong U.S. competition. *Bloodhound* is capable of interception from sea level to 60,000+ feet and has a continuous-wave guidance system, which gives very high accuracy and makes jamming very difficult. The *Bloodhound* weapons system is produced by a consortium: Bristol Aircraft (airframe), Ferranti (missile electronics), Associated Electrical Industries (environmental radar), and Bristol Siddeley (*Thor* ramjets).

●

The 200th English Electric (BAC) Lightning fighter was on the line in July and production is likely to continue for several years. *Lightning Mk. I* production is almost completed and this will be followed by the Mark 2, 3, and 4 (trainer) versions. The first production Mark 2 flew on Tuesday, July 11th. No details have yet been revealed, but the *Lightning* is now believed to have improved electronics and other refinements. The Mark 3 may have an uprated *Avon* engine with improved specifics, the *Red Top* air-to-air missile, and ground-controlled automatic landing and interception techniques which have previously been only hinted at. The Mark 4 two-seat version may be developed in a combat role as well as in a trainer version.

Lightning development is likely to continue through the 1960s, with the emphasis being on improved fire-control, weapons, range, and engine performance. Introduction of long-range fuel tanks, now developed, will greatly extend range. English Electric currently has three facilities engaged on *Lightning* production: front fuselage and wings at Preston; rear fuselage and tailplane at Accrington; final assembly at Samlesbury (all in Lancs.). Flight testing is carried out at the company's Warton (Lancs.) facility. Over 8,000 people are currently engaged on *Lightning*, *Canberra* and *TSR.2* work at the company plants.

●

First West German licence-produced Fiat G.91 strike fighter made its first flight from Dornier's works field near Munich on July 20th. Germany's Southern Group (Dornier, Heinkel, and Messerschmitt) is to build a total, 294 Fiat G.91s for the Air Force.

●

Messerschmitt will soon occupy its new facility at the Government-built Manching Airport industrial plant and will start operations by the end of the year. In July a sizeable section of the new Manching buildings was handed over to the Air Force Test Centre, and this facility should be in full operation by 1963. At Manching, Messerschmitt will have three large halls, two to take over maintenance currently handled at the Munich-Riem plant, and one for final assembly of the 210 F-104Gs to be manufactured by the Arge Sud group. Flight testing of the German-built F-104Gs should start in October, and Manching is to have a new 11,500-ft runway parallel to the existing runway (a West German Air Force Reconnaissance Squadron is based at the field).

●

Nord-Aviation booked export orders valued at NF 50 million ($10m) during the first half of 1961. Half were for aircraft, including *Noratlas* for Portugal, with the rest covering the SS.10 and SS.11 anti-tank missiles, the CT.20 and CT.41 target drones, and simulators. Major customers were: West Germany, Sweden, Great Britain, Norway, Israel, Portugal, USA, and Canada. Nord reported a profit of NF 7,021,000 ($1.4m) for the 1960 year against NF 4,470,000 ($894,000) in 1959.

●

Nord-Aviation has signed a contract with the U.S. Army giving the United States licence production rights for the SS.11 anti-tank missile. This move was forecast back in April 1959, when the U.S. Army first started evaluation trials with the SS.11. Under the new contract, the United States will also receive rights to any future modifications or developments of the weapon carried out by Nord-Aviation.

●

Costruzione Aeronautiche Giovanni Agusta built in all 673 helicopters at its Cascine Costa plant during the period May 14th, 1954 (first production under the Bell licence) to June 30th, 1961, and also produced spares equal to the value of 177 more helicopters. Export sales have accounted for 72% of production, with orders booked from Austria, Denmark, England, France, Netherlands, Norway, Portugal, Sweden, Switzerland, Spain, West Germany, and Yugoslavia. Spares have also been supplied to Middle East countries.

●

Compagnia Generale Automazione SpA is a new Italian subsidiary in Rome formed by Laboratory for Electronics Inc. in a joint venture with International Commercial Company (holdings 70/30%). LFE's new International Operation achieved sales totalling nearly $1 million during its first year of existence with considerable expansion of the facilities of several affiliated companies such as Segnalamento Marittimo ed Aereo (Florence). LFE has just received a $36,000 Air Force contract for airport surface-detection equipment which is to be manufactured by Segnalamento Marittimo ed Aereo. The forthcoming LFE-Tracerlab Inc. merger, already approved by both Boards and to be voted on at stockholders' meetings on September 12th, will give LFE a 65/35 military/commercial sales ratio.

Military Affairs

U.S. Army Light Observation Helicopter (LOH) programme (cf. No. 7/1961) now includes a third competitor for the lucrative contract—Hughes Aircraft Co.'s 369 design. Winnersof the preliminary design evaluation announced on May 19th were Bell Helicopter Co. with the D-250, and Hiller Aircraft Corp. with the Hiller 1100 (chosen from 18 designs submitted by 12 companies). With the approval of an $8 million reprogramming, the Army now sees sufficient funds available also to bring Hughes' promising design into the competition, formerly ruled out on a cost basis. A bidders' conference was scheduled for July to negotiate contracts for delivery of five prototypes by each company. The LOH programme eventually may run to 4,000-5,000 aircraft for the Army, at a cost of up to $200 million. The winning design will be powered by an Allison T-63 gas turbine engine and will replace three aircraft currently in inventory —the L-19 fixed-wing *Bird-Dog*, and the H-13 and H-23 *Raven* helicopters.

●

U.K. and U.S. Governments have agreed to establish a £13 million ($36.4m) "ground read-out" station at RAF Station Kirkbride, Cumberland, for the U.S. *Midas* missile defence alarm system satellite. The United States will bear £10 million ($28m) of the cost with the U.K. paying £2-3 million ($5.6-8.4m). The Kirkbride ground station will be operated and commanded by RAF personnel. The U.S. is to supply and instal special equipment and the communication links with the United States, while the U.K. will provide accommodation and communication links to the U.K. authorities.

●

British Royal Air Force and Fleet Air Arm have been discussing another generation of fighters to become operational after the *Lightning*, and the question will be whether the two requirements can be combined. Current reports indicate that the RAF is interested in an aircraft with VTOL characteristics, but the Navy has no such need. Speeds for aircraft in both cases would be around Mach 2. The RAF could have a straight fighter development of the *TSR.2*, which would provide a suitable platform for a new long-range, air-to-air, guided weapon. A *TSR.2* variant, suitable for operation from rough, 600-yd airstrips, would also be able to use Middle and Far East airfields in a local war capacity.

●

West Germany's 1962 Defence Budget will total approximately DM 13,500 million ($2,375m), an increase of DM 2,300 million ($575m) over the current year. Over 30% of the 1962 funding will go towards armaments procurement.

●

The Sudan Air Force has ordered an unspecified number of Hunting Aircraft (BAC) *Jet Provosts* and spares. Powered by Bristol Siddeley *Viper* engines, the Sudanese *Jet Provosts* will be fitted with machine guns and will also be able to carry rockets and bombs. A number of Sudanese pilots have already completed a *Jet Provost* conversion course at RAF Flying Training School Syerston (Notts.). The Sudan Air Force already has the earlier piston-engine *Provost* operating in the trainer/military configuration. *Jet Provost* is employed by the British Royal Air Force as a basic trainer, and is also in service in its armed version with the Royal Ceylon Air Force.

(Continued on page 1057)

Regional control radar at BORDEAUX-MÉRIGNAC

To ensure the rigorous control of civil aircraft over central and southern France (three-quarters of the country), the Service de la Navigation Aérienne has chosen Compagnie Française THOMSON-HOUSTON.

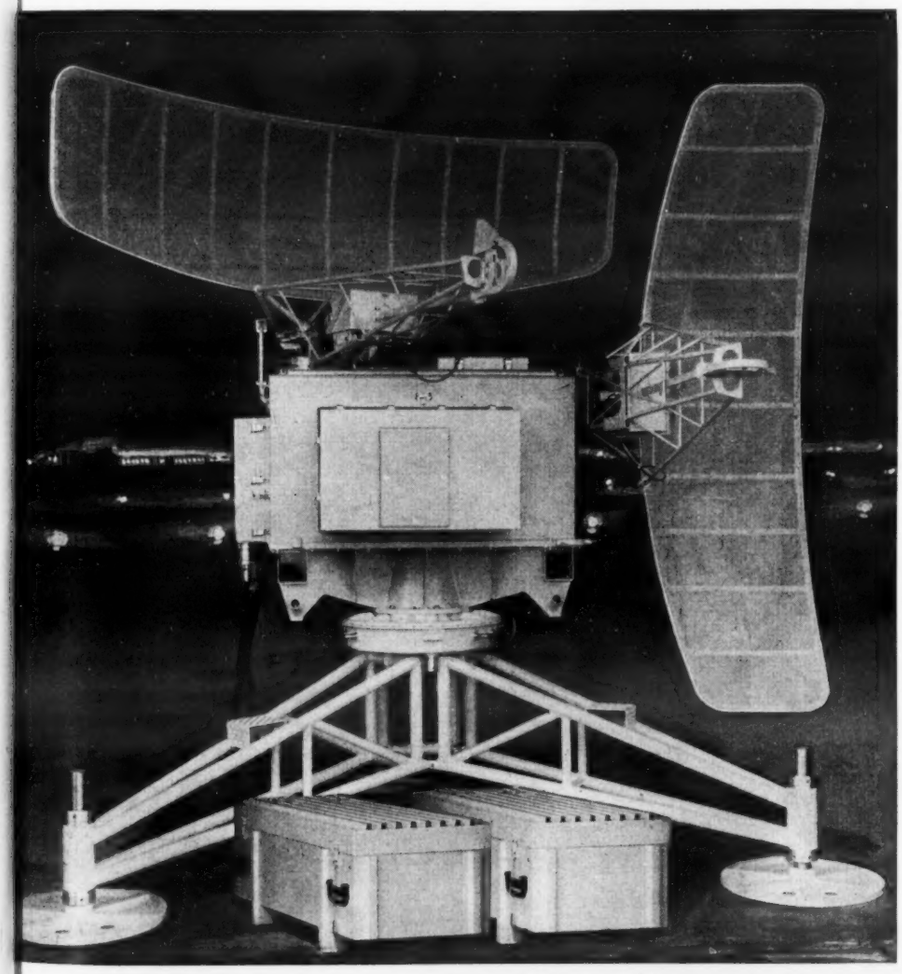
The THOMSON-HOUSTON solution is at present the most advanced as regards the volume of airspace under control.

Moreover, it offers a simple and entirely new solution to the difficult problem of ground echoes.

Power for transmission is supplied by the classic ER 410/D transmitters built by Compagnie Générale de T.S.F.

FRANCE, a vital link in the European air traffic chain, is thus in the forefront of progress in the important field of air traffic control.

THOMSON CFTH HOUSTON



TH.D.1013 light approach radar

Rapid installation
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STC AIRBORNE RADIO STR.18 series

This well-known range of H.F. Transmitters and Receivers is widely used in aircraft of many of the world's leading airlines and air forces.

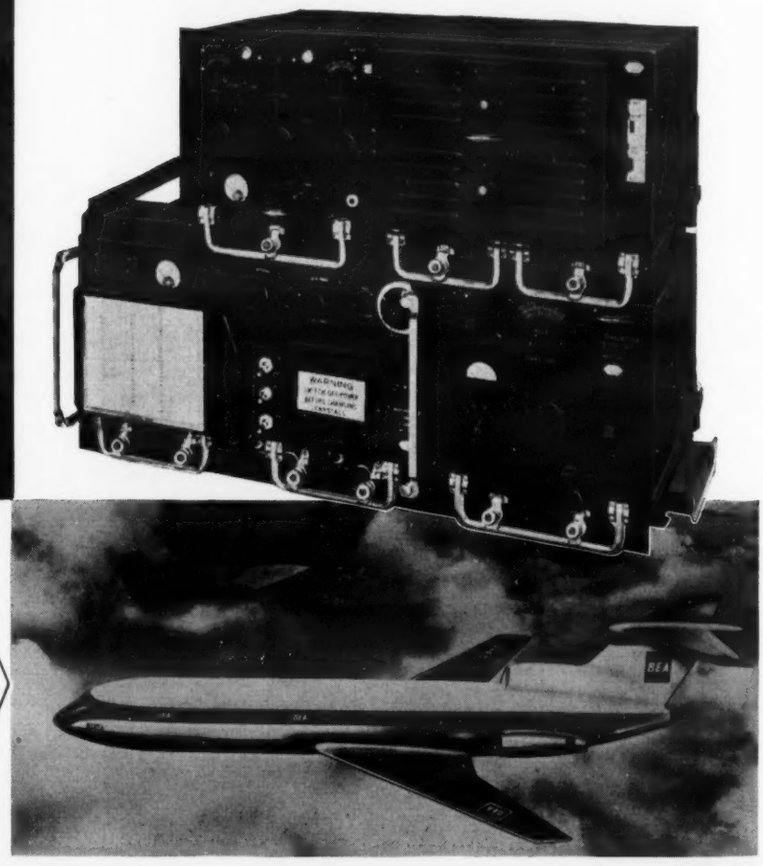
Operating as pilot-controlled radio-telephony equipments, they also provide facilities for C.W. and M.C.W. operation at the main equipment.

The aerial used may be either the conventional wire type or a suppressed notch.

STC engineers have conducted extensive development on notch aerial systems, and the Company is now able to supply these to suit the specific requirements of individual aircraft.

The STR.18 equipments have a frequency range of 2.8 - 18.1 Mc/s with an output power of 100 watts, the STR.18-B/2 providing 24 pre-set channels and the STR.18-C and STR.18-C/1 each operating on any one of 100 channels.

The STR.18-B/2 and STR.18-C require power supplies of 28 volts d.c. and 19 volts d.c. with internal blower cooling. The STR.18-C/1, operating with a 28 volts d.c. supply only, is cooled by the aircraft centralized cooling system.



The STR.18-C/1 and notch aerial have been specified by British European Airways for their "Trident" fleet of aircraft.

These equipments are described in Radio Leaflets 207, 216 and 262.

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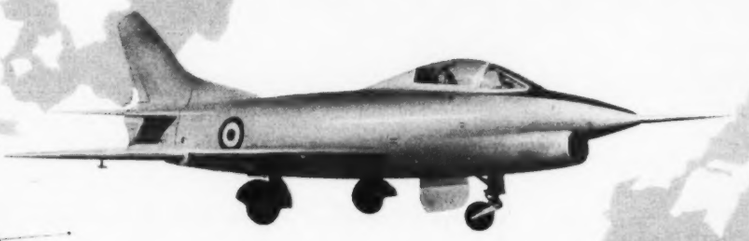
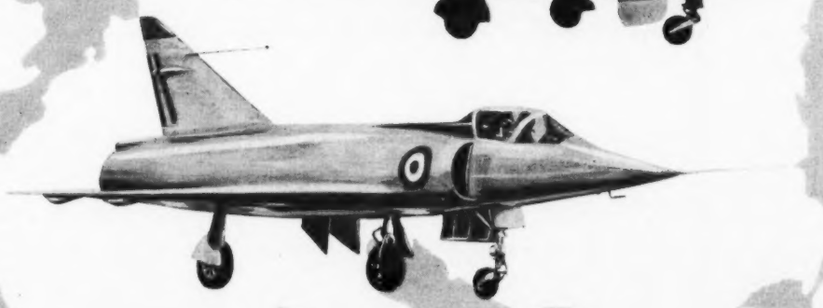
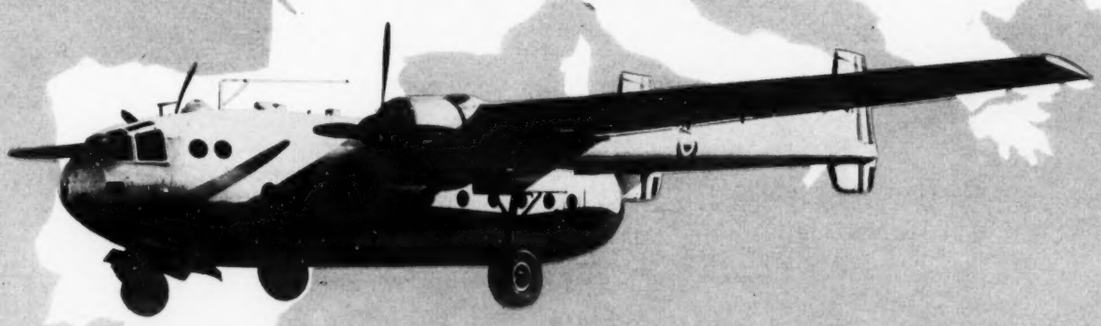
in undercarriages
and hydraulic systems







MESSIER equipment is used in

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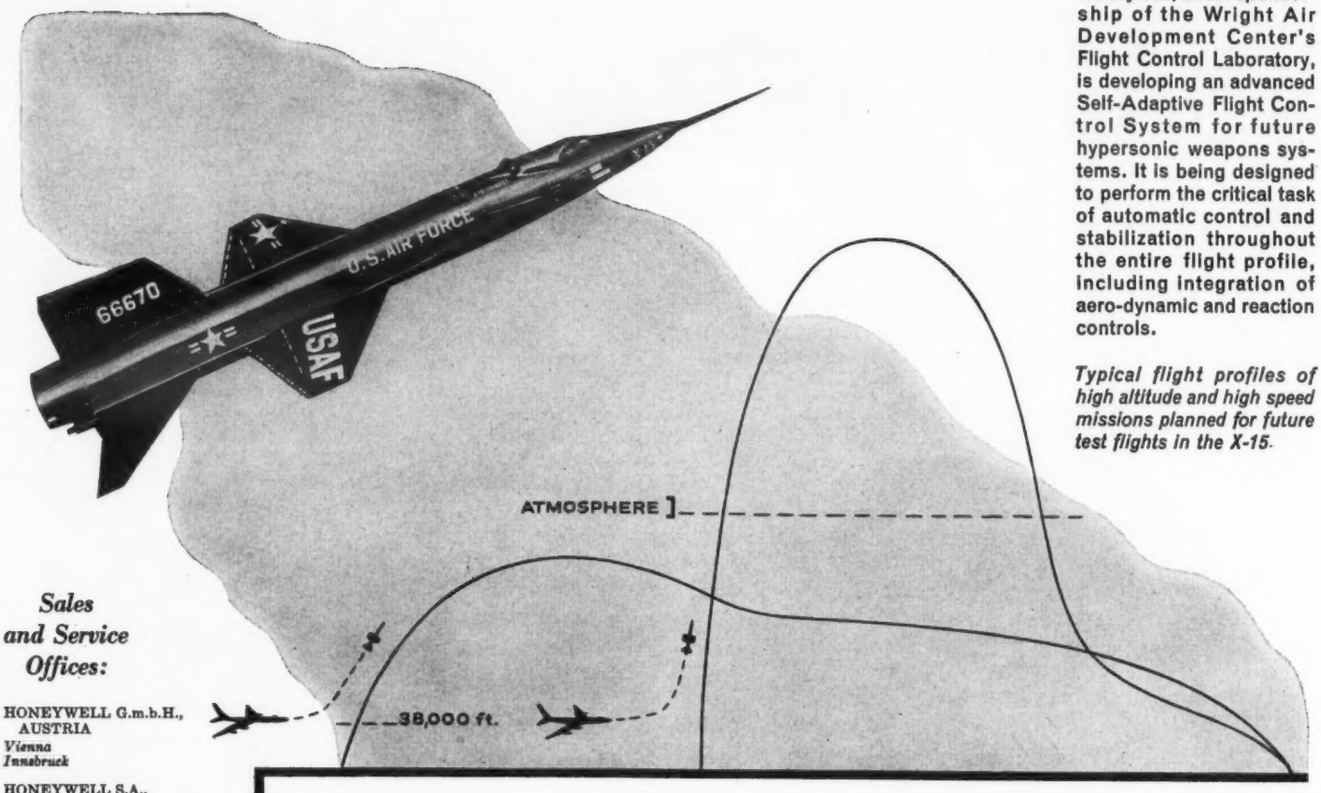

Honeywell, under sponsorship of the Wright Air Development Center's Flight Control Laboratory, is developing an advanced Self-Adaptive Flight Control System for future hypersonic weapons systems. It is being designed to perform the critical task of automatic control and stabilization throughout the entire flight profile, including integration of aero-dynamic and reaction controls.

Typical flight profiles of high altitude and high speed missions planned for future test flights in the X-15.

FROM SEA LEVEL TO SPACE

The Honeywell Self-Adaptive Autopilot is designed to deliver optimum performance for every type of flight vehicle

The simplest, most reliable automatic flight control system yet designed, the Honeywell Self-Adaptive Autopilot operates independently of air data information and complex gain scheduling. Adjusting itself in response to its own performance, it is unaffected by changes in aero-dynamic characteristics. Here are some of its advantages.

Simplicity—Needs no air data information for gain scheduling—is not significantly affected by design modifications in aircraft, asymmetric loading or center of gravity changes—is easily mechanized and needs little tailoring to specific vehicles—is 45% smaller and lighter—requires 50% less power.

Reliability—Provides major reduction in required components, sub-assemblies and wiring—uses solid state amplifiers and switching logics.

Economy—Assures significant cost reductions through low initial cost of design and development, and simplified logistics, training and maintenance.

Versatility—Can be quickly adapted without major modifications to business aircraft, helicopters, drones, supersonic fighters and bombers, missiles and the latest hypersonic research vehicles. The Honeywell Self-Adaptive Autopilot System is now undergoing flight tests in both the supersonic F101A and "light-twin" Cessna 310 aircraft—impressive evidence of its wide range of adaptability. To learn about fitting it into your plans, write Honeywell, International Division, Minneapolis 8, Minnesota, U.S.A.

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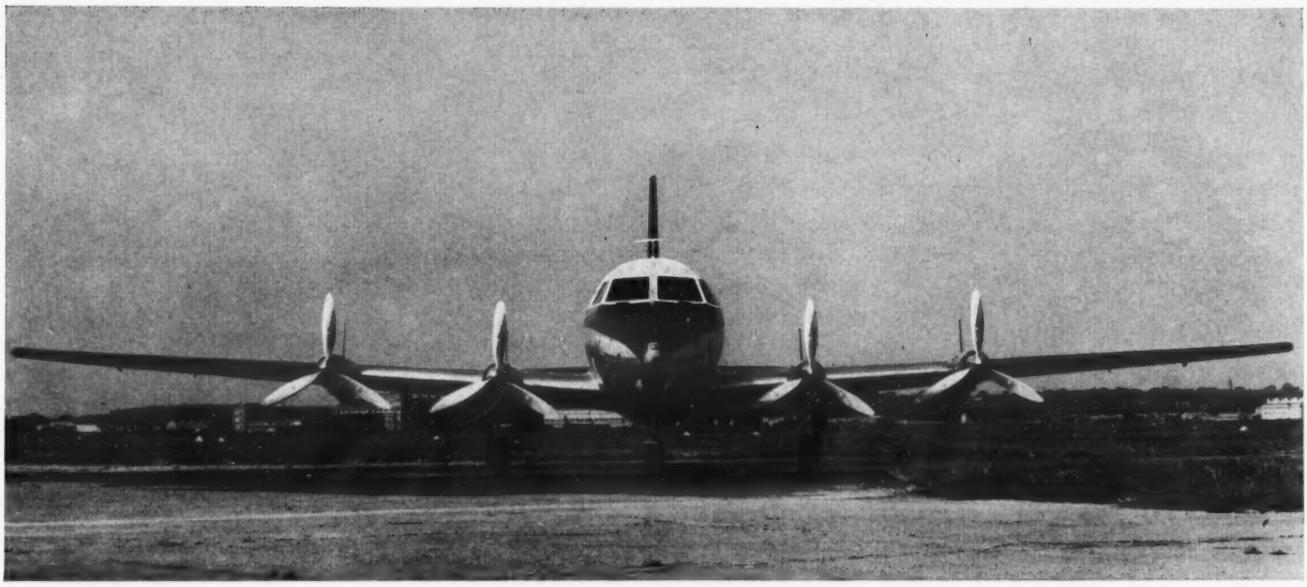

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CAPACITY well in line with the frequency of short haul services—
SERVICE SPEED in excess of 312 m.p.h.—
REDUCTION in DIRECT OPERATING COSTS—
the SAFETY, PLEASURABLE TRAVEL, and COMFORT of a large, modern airliner.

As an EXECUTIVE AIRCRAFT, the POTEZ 840 is impressive for its takeoff and landing capabilities, which enable it to use all existing runways and for its range of up to 2,000 miles, and for the, as yet unparallelled, extra speed it offers the business man requiring direct and reliable communications.

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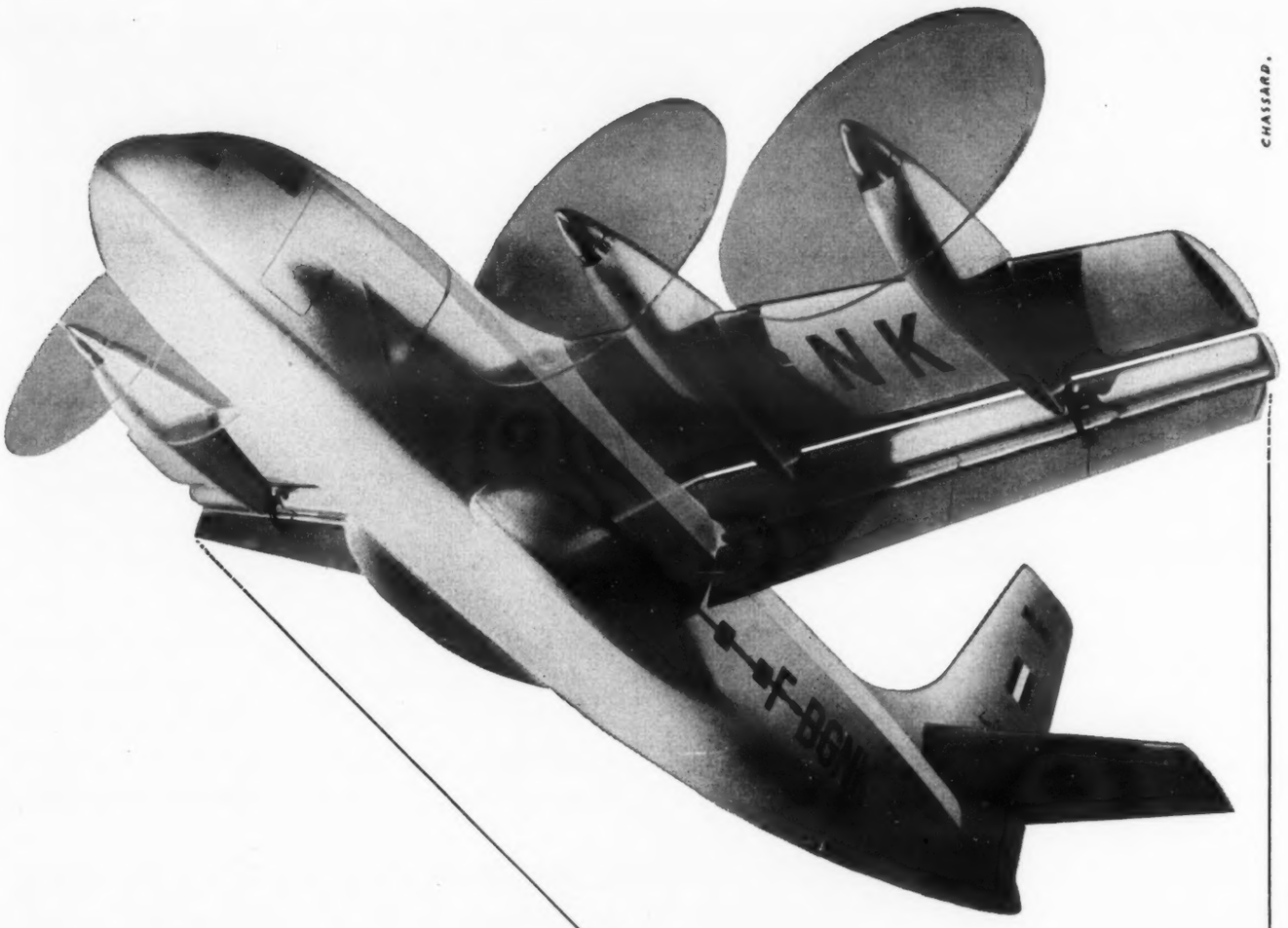

CHASSARD.

Outside the existing network of major air routes with the long runways required by conventional airliners, the BREGUET 941 is in its element ; designed to operate from small, unprepared landing grounds, it can carry, at a speed of 250 m.p.h., not only 40 comfortably seated passengers but also an impressive volume of freight (as much as 5 tons on 1,000-mile stage lengths). The BREGUET 941 will bring air transport to areas hitherto inaccessible owing to the absence or inadequacy of landing grounds, thus giving airlines almost unlimited scope for their activities.

BREGUET 941

From the coracles of prehistoric times to the jet airliners of to-day, fast efficient transport has been the key to the progress of civilization. But with each major improvement, the associated problems of operating each form of transport have grown in complexity, and now demand as much attention as the improvement of the land, sea or air vehicles themselves. In the case of aviation, more airlines, faster aircraft, bigger airports - all combine to compel those in charge of air traffic to cry out for modern, fast data processing equipment. SATCO automatic air traffic control is a practical solution to their problems.

EFFICIENT TRANSPORT MEANS PROSPERITY

SIGNAAL

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SIGNAAL AUTOMATIC AIR TRAFFIC CONTROL

Satco comprises the ground equipment to predict, coordinate, check and display the movements of air traffic en route and in terminal areas. It provides an extremely rapid method of calculating flight paths, for assessing potential conflicts and for coordination between Area Control Centres. Special features are included for military / civil coordination and for the control of jet-powered traffic.

The system has been ordered by The Netherlands Government and the first phase is now on operational test.

Beudvin

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new transistorized radar gives same full service at half the weight

Collins new WP-103 Weather Radar System packs an accurate, continuous weather picture into less than fifty pounds . . . probes conditions up to 150 nautical miles ahead. Low volume and power requirements, plus maintenance-simplifying transistorized modular construction, mean new flexibility for your aircraft. ■ Collins weather radar features a new fully stabilized antenna available in a 12″ or 18″ dish to match your space requirements. Special Iso Echo contour display clearly defines corridors of milder weather, and sharp, black areas of intense activity in a 120° sweep, ±15° tilt. Bright Tube permits daylight operation without hood. ■ Let your Collins dealer show you how the WP-103 Radar can add safety and dependability to your aircraft's operation, or write Collins Radio Company, International Division, for complete information.

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COLLINS
INTERNATIONAL DIVISION

(Continued from page 1048)

Aircraft and Engines

Douglas Aircraft Corporation's A4D-5 Navy strike aircraft made its maiden flight from Edwards Air Force Base, California, last month. Powered by a Pratt & Whitney J52 engine, the A4D-5 is an improved version of the Douglas A4D-1 *Skyhawk*. The A4D-5 has a considerable striking power and is capable of carrying atom bombs, guided weapons, rocket projectiles, machine guns and other weapons. The size of the A4D-5 is less than half that of many currently operational jet fighters, and the folding wings normally required for carrier-based aircraft have not been fitted.

●

The Federal Aviation Agency has issued a Class 1 Provisional Certificate for the Lockheed C-140 *JetStar*. Production versions of the *JetStar* had logged more than 550 flight hours at mid-July.

●

The Boeing 707-320B long-haul jet is powered by four Pratt & Whitney JT3D-3 turbofan engines of 18,000 lb thrust each and has the following data: gross weight 317,500 lb; maximum landing weight 207,000 lb; fuel capacity 23,815 U.S.gal; cargo volume 1,625 cu.ft; cabin layout for 186 economy-class passengers, or 34 first-class and 99 economy-class plus a 10-seat first-class lounge in a mixed-class configuration.

●

The Royal Canadian Air Force has ordered two Boeing Vertol 107 helicopters, which will be designated CH-113. The two aircraft are to be operated by the RCAF as search and rescue vehicles and will carry highly-specialized electronics equipment. It is now known that the CH-113 will be capable of carrying external loads of up to 10,000 lb. Other details are: cruising speed 150 m.p.h.; gross weight 18,700 lb; hover ceiling at gross takeoff weight 7,400 ft with ground effect; maximum rate of climb 1,600 f.p.m.; powerplant two General Electric T58-8s, each of 1,250 s.h.p.

●

General Dynamics/Convair is rumoured to be working on a short-haul jet transport project powered by two (Pratt & Whitney or General Electric) 14,000-18,000 lb thrust class jet engines mounted at the rear of the fuselage. Reports indicate that the aircraft will probably be in the 70,000-80,000 lb weight class, designed for 800 n.m. flight stages, and with a maximum takeoff distance of 4,000 ft.

●

The Morava L-200A, now in production, is powered by two 210 h.p. M.337 six-cylinder engines incorporating compressors and direct fuel injection. The L-200A has a considerably improved performance compared with the original *Morava* L-200 model (two 160 h.p. Walter Minor 6-IIIs). New technical data are: maximum speed 165 knots at 6,000 ft and 4,300 lb takeoff weight; service ceiling 18,700 ft; takeoff distance over a 50 ft obstacle 1,260 ft; landing distance over a 50 ft obstacle 1,970 ft; range 810-890 n.m.; span 40.35 ft; length 28.2 ft; wing area 186.2 sq.ft. Relatively large numbers of the *Morava* have already been delivered.

●

Some details are now available on the 9K version of the SNECMA *Atar* jet engine at present undergoing bench testing. Compared with earlier versions, the 9K has a modified compressor (transonic first and second stages) with a compression ratio quoted as 6.5. An appreciable increase appears to have been achieved in turbine inlet temperature by employment of new materials. Dry thrust is given as 10,360 lb, and thrust with afterburner 14,770 lb. Reports indicate that the Royal Australian Air Force may select the *Atar 9K* to power its *Mirage IIIs* on order from Dassault (if the 9K is not chosen then the *Atar 9C* will be employed).

●

The Turboméca Bastan turboprop engine had completed a 1,000-hour test period on June 3rd according to a company statement. The test programme consisted of 500 two-hour cycles, and the 1,000 s.h.p. engine was run at 33,500 r.p.m. throughout the programme, which also included testing of the reliability of the blade pitch changing mechanism.

●

English Electric (BAC) started flight testing of the first production *Lightning Mark 2* fighter with a maiden flight from the Samlesbury (Lancs.) works field on July 11th.

●

The latest version of the Napier Gazelle turboshaft engine is designated "*18*", and will give 1,850-1,900 s.h.p. performance class. The *Gazelle 18* is likely to be the basic powerplant for the British Royal Navy's Westland *Wessex 3* helicopter.

●

The Rolls-Royce RB.172 mentioned in connection with the de Havilland DH.126 feeder-liner project is now known to be in the 3,500 lb thrust class.

●

Boeing Vertol Division has received the Federal Aviation Agency's provisional Class 1 certification for the Vertol 107 twin-turbine transport helicopter. The aircraft can, as a result, now be utilized for training, route testing, and demonstration. The first production model 107 began flight testing on May 19th and two pre-production models are also being used in the FAA test programme. A prototype (military), which was flight tested in 1958, is at the moment making a second demonstration tour of Western European countries.

Missiles and Space

North American Aviation's Rocketdyne Division has started first test firings of a complete F-1 rocket engine for the National Aeronautics and Space Administration's Marshall Space Flight Center (Huntsville, Ala.). Before the tests began, a considerable number of static firings had been conducted with various components of the engine during the two-and-a-half years it has been under development. The present tests are being conducted at the Edwards Rocket Test Center in California and the complete F-1 is being tested so as to gradually build up to its rated thrust of 1.5 million lb, and up to two-and-a-half minutes firing time. A thrust of 1 million lb was attained in the first firings of the present series. The F-1 is being developed for the *Nova* launch vehicle, which may have eight F-1 engines clustered to provide up to 12 million lb of thrust. Latest reports indicate that the engine's weight may be greater than originally planned, and this may reduce the overall capability of the vehicles for which the engine is planned.

●

Further details are now available on the Shavit II (Meteor) altitude research rocket launched from Israel last month. Reports from Israel stress that the *Shavit II* was designed and built entirely with domestic resources. The primary function of the rocket is meteorological research and the Israeli newspaper "Haboker", which is close to government sources, states that further launchings are programmed for the near future. Israeli scientists are rumoured to be already working on the development of more efficient rocket types for altitude research work. Pictures so far available show that the *Shavit II* is clearly a two-stage rocket with four (obviously fixed) stabilization surfaces at the rear of the first stage.

●

The Martin TGAM-83, a trainer version of U.S. Air Force's GAM-83 *Bullpup* air-to-surface missile, has now become operational. A series of flight tests with the TGAM-83 has been carried out at Eglin Air Force Base, Florida, while the pre-production version of the missile has been undergoing testing by pilots of the USAF's Tactical Air Command. During the Eglin AFB tests the TGAM-83 trainer reached speeds of near Mach 2 and a range of 30,000 ft. The TGAM-83 is approximately 8 ft long and weighs 125 lb. The operational GAM-83A is approximately 10 ft long with a weight of about 600 lb. Powerplant used for the TGAM-83 is the HVAR rocket motor with a thrust of 5,000 lb.

Accessories and Equipment

Bauscher is producing a mobile power generator which is capable of supplying power to the Boeing 707, Douglas DC-8, Convair 880 and 990 aircraft, and start the engines of the *Caravelle*, *Britannia*, and *Viscount*. Technical details of the generator are as follows: driven by either diesel or electric motor; brushless 400 c/s generator, 60 kVA, 200/108 V; direct current 200 A, 112 V, and 750 A, 28 V with 2,000 A peak output. Vehicle speed is 5 m.p.h. and it can be used as a trailer at speeds of up to 15 m.p.h. Bauscher also produces mobile and fixed high-pressure compressors for starting jet engines; output pressure is 3,750 p.s.i.

●

Telefunken is offering an HF bandwidth spectrograph, designated Type SiG 488/1, which is designed for rapid spectral analysis of HF oscillations. Analysis range of the spectrograph is 25 Kc/s; analysis speed 2-3 seconds. Special additional photo equipment (with automatic camera) enables the spectrum to be photographically recorded.

●

Telefunken is also producing a magnetic tape digital memory, known as the MDS 251, for recording binary coded values. Seven channels are available for recording with an eighth for timing. Storing capability 14 bits per mm; band speed 250 cm/s or 500 cm/s.

●

Carl Zeiss is offering an electron-beam equipment for high-speed milling and boring work. The equipment permits working of even the hardest materials. Energy of up to 10,000 kW per cm^2 is applied to a minute area of the working surface, evaporating the material at the actual point of contact, but not affecting the surrounding area. Preliminary information shows that the equipment can produce slots as small as 1/100 mm.

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INTERNATIONAL MEETINGS AND CONFERENCES

Aug. 7th-9th: Douglas Aircraft Company, International Symposium on Space Age Astronomy. California Institute of Technology.

Aug. 15th-17th: University of Michigan, Cryogenic Engineering Conference. Ann Arbor, Mich.

Aug. 16th-18th: American Rocket Society. International Hypersonics Conference. Cambridge, Mass.

Aug. 18th-20th: International Symposium on Chemical Reactions in the Upper and Lower Atmosphere. San Francisco.

Aug. 22nd-25th: IRE, Western Electronics Show and Conference (WESCON). Cow Palace, San Francisco, Calif.

Aug. 23rd-25th: ARS, Biennial Gas Dynamics Symposium. Evanston, Ill.

Aug. 23rd-27th: FAI European Air Rally, organized by the Austrian Aero Club.

Aug. 23rd-Sept. 2nd: National Radio and Television Exhibition. London.

Aug. 25th-Sept. 3rd: German Radio, Television and Phonographic Industries Exhibition. Berlin.

Aug. 27th-Sept. 3rd: International Parachuting Contest, organized by Svenska Fallskärms-Klubben. Uppsala (Sundbro).

Aug. 28th-Sept. 1st: Second International Heat Transfer Conference. University of Colorado. Boulder, Colo.

Aug. 28th-Sept. 1st: Japanese Rocket Society, 3rd International Symposium on Rockets and Astronautics. Tokyo.

Aug. 29th: ICAO Diplomatic Conference on Third Party Carriage. Montreal.

Aug. 30th-Sept. 1st: American Institute of Mining, Metallurgical and Petroleum Engineers, Third Annual Semiconductor Conference. Los Angeles.

Sept. 1st-8th: International Exhibition of Radio, Television and Electronic Equipment. Amsterdam.

Sept. 3rd-12th: Seventh European Machine Tool Exhibition. Brussels.

Sept. 4th-9th: International Association for Analogue Computation. Belgrade.

Sept. 4th-10th: SBAC Flying Display and Exhibition. Farnborough.

Sept. 4th-14th: RAeS and IAS, Eighth Anglo-American Aeronautical Conference. London.

Sept. 6th-8th: IRE, 1961 Joint Nuclear Instrumentation Symposium. North Carolina State College, Raleigh, N.C.

Sept. 6th-8th: National Symposium on Space Electronics and Telemetry. Albuquerque, N.M.

Sept. 6th-8th: Massachusetts Institute of Technology, International Symposium on the Transmission and Processing of Information.

Sept. 10th: International Landing Contest. Saint Nicolas Waes, Belgium.

Sept. 10th-12th: National Aeronautic Association, 1961, National Convention. Westbury, L.I., N.Y.

Sept. 10th-24th: International Technical Fair. Brno.

Sept. 12th-14th: National Association of State Aviation Officials. Deauville Hotel, Miami Beach, Fla.

Sept. 13th-17th: Second International Rally, organized by the German Aero Club. Baden-Baden.

Sept. 13th-21st: Second World Congress of Flight. Las Vegas, Nev.

Sept. 14th-15th: Institute of Radio Engineers, Conference on Technical Scientific Communications. Philadelphia.

Sept. 14th-25th: National Electronics, Radio and Television Exhibition. Paris.

Sept. 19th: ICAO, Fourth North Atlantic Regional Air Navigation Meeting. Paris.

European Space Research Projects

While Soviet and American space research is forging ahead, and has already chalked up its first successes, Western Europe is only now bestirring itself to bring a European space research programme into being. As always, when a European cooperative effort is sought, historical differences and national peculiarities make for slow and cautious progress. Without claiming to be comprehensive, the following survey describes a few of the European space research efforts.

COPERS: At a meeting of COSPAR (Committee on Space Research), a special committee on space research of the International Council of Scientific Unions, held in Nice in January, 1960, Professor Pierre Auger, President of the French Comité de Recherches Spatiales, and his Italian colleague, Professor Eduardo Amaldi, took the initiative in proposing a European space research centre, modelled on CERN, the European Nuclear Research Centre, Geneva. The idea met with a favourable reception and, after preliminary contacts with European scientific and political circles, Mr. Max Petitpierre, the then President of the Swiss Confederation, called a conference at CERN headquarters in Geneva on 28th November 1960. This was attended by Government representatives from Belgium, France, the German Federal Republic, Great Britain, Italy. The Netherlands, the three Scandinavian nations, and Switzerland. The upshot of this conference was the formation of the European Preparatory Commission for Space Research, known as COPERS (Commission Préparatoire Européenne de Recherches Spatiales). Spain later joined as a full member and Austria as an observer. Sir Harrie Massey of England was elected President, with Professors L. Broglio (Italy) and H. C. van de Hulst (The Netherlands) as Vice-Presidents. Professor P. Auger is Secretary-General, and his deputy J. Mussard (Switzerland). This Commission's task is to lay the groundwork for the establishment of the European Space Research Organization (ESRO). The first meetings, held in March of this year in Paris and Stockholm, were principally devoted to financial, administrative, and organizational matters. ESRO's activity will be strictly scientific, and in this respect it follows the example set by CERN; its task will however be a much more delicate one, since space research is, from the outset, handicapped by political and military considerations. If and when ESRO will actually come into being has not as yet been established, but its existence would undoubtedly do much to further the efforts of European industrial and scientific circles towards peaceful space research and bring them to fruition.

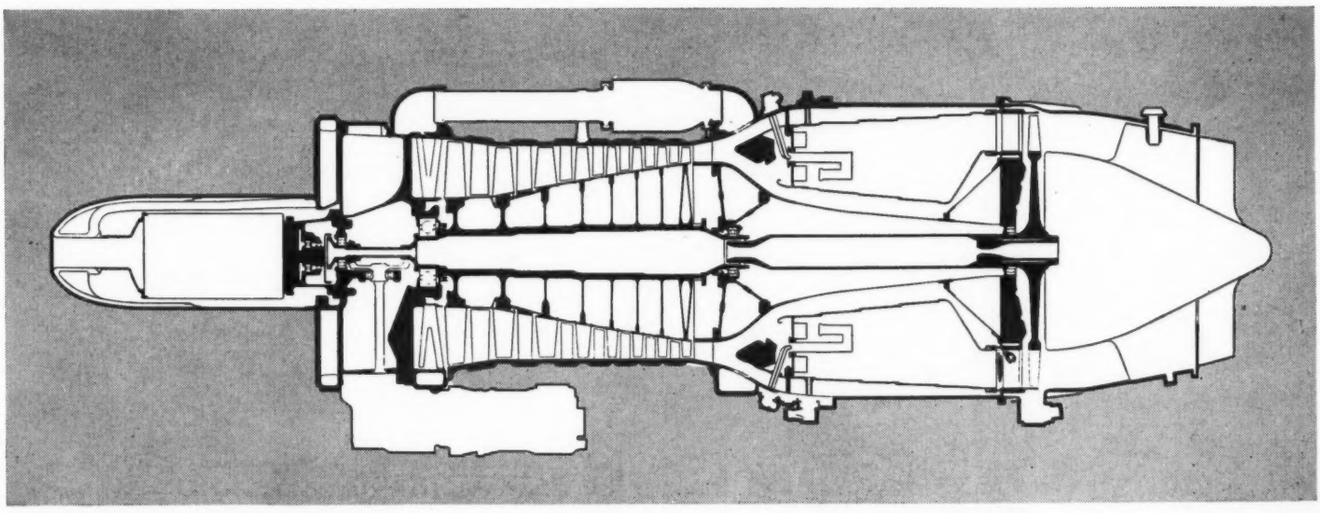
STRASBOURG: Once again, Strasbourg, seat of the Council of Europe, has become the centre of the efforts directed towards European cooperation. Following the decision of the British Air Ministry to abandon development of the *Blue Streak* ground-to-air missile as a weapons system, Air Minister Peter Thorneycroft has proposed to his continental friends the use of the *Blue Streak* as a carrier rocket for a European satellite. After exploratory visits to West Germany, Denmark, Norway, Sweden, Italy, and Switzerland, and intimate discussions with France, all these countries plus Spain, The Netherlands, and Austria, were invited by Great Britain and France to attend an international space travel conference in Strasbourg on January 30th, 1961. The results were most promising; as these pages go to press, firm promises have been received from West Germany, France, and Italy, to collaborate in the prosecution of a European space research programme based on the British *Blue Streak*. What does this Strasbourg space research programme imply? Its backbone is *Blue Streak*, for which the financial outlay will reach £60 million. Of this sum, Great Britain would be ready to contribute £23 million. The other nations would contribute the following sums (figures are in sterling): Belgium, £1,986,000; West Germany, £13,200,000; Denmark, £953,000; France, £14,400,000; Italy, £6,800,000; The Netherlands, £1,843,000; Norway, £770,000; Austria, £924,000; Spain, £2,055,000; Sweden, £2,020,000; Switzerland, £1,576,000. These figures, which date from early 1961, should be treated with reserve, as they may have undergone some alteration.

From the technical point of view, it seems certain that the British *Blue Streak* would be used as the first stage of a European carrier rocket. The choice for the second stage fell on the French *Véronique*, and it is likely that this decision can be considered final. The third stage will be produced as a joint European endeavour with the German Federal Republic as the main partner. The launching site for this carrier rocket to be produced by European teamwork has not been selected. The British prefer the Woomera Range in Australia, where preparations are already under way. Further possibilities mentioned include an area in Somaliland and a floating launch platform. The assumption in London is that the Strasbourg programme can be brought to successful completion in about five years.

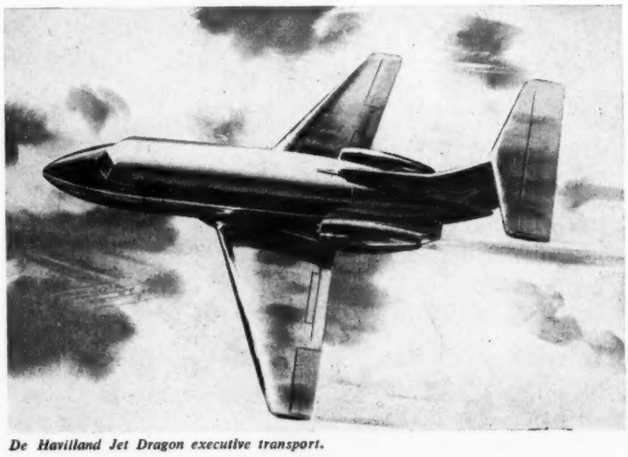
EUROSPACE: It is clear from the preceding that the European space research programme has thus for been primarily a question for politicians. It is, therefore, hardly surprising that private enterprise has also spoken up. Late in May of this year, concerns engaged in rocket research in France, Italy, West Germany, Great Britain, Belgium, Holland, and Sweden set up a private committee for European space research, at the instigation of the British Hawker-Siddeley concern and the French SEREB (Société pour l'Etude et la Réalisation d'Engins Balistiques). The inaugural meeting was attended by 55 scientists from 30 private concerns in the aircraft, electronics, and chemical fields. The President of the Committee is Jean Delorme, Chairman of the French Air Liquide concern. At the end of June, this Committee, which had meanwhile been baptized *Eurospace*, proceeded to form various working groups. These will concern themselves with the following matters: long-range communications for civil purposes; navigation satellites for civil purposes; and anti-satellite systems for military purposes. The first general meeting of Eurospace is scheduled to be held in Paris in September of this year, when the first reports on the proposed European space research programme are due to be submitted. The Board of Directors of Eurospace will then recommend that Eurospace join the Association Internationale des Constructeurs de Matériel Aérospatial (formerly the Association Internationale des Constructeurs de Matériel Aéronautique). In this event, the Chairman of Eurospace, Mr. Jean Delorme, would take over the vice-chairmanship of AICMA, thus ensuring complete coordination of the activities of both organizations.

BS
AERO POWER

New Viper provides reliable, low-cost power for executive jets



The Bristol Siddeley Viper 20 is now under development for the next generation of light executive transports. This new version is basically a Viper 11 with a "zero" stage added to the compressor which gives a 20% increase in mass flow, a reduced turbine entry temperature and an improved specific fuel consumption. Like all its predecessors, the Viper 20 retains the basic design concepts of a simple, reliable engine with high thrust at high altitude and *low first cost.*



De Havilland Jet Dragon executive transport.

Delivering 3,000-lb thrust at take-off for a sea-level specific fuel consumption of 0.985 lb/lb/hr, the Viper 20 has potential for development to still higher thrusts and lower specific fuel consumptions.

SELECTED FOR THE JET DRAGON

The Viper 20 has already been selected for the Jet Dragon—De Havilland's new jet executive aircraft which will carry up to 9 passengers in great comfort at a cruising speed of 500 mph. An initial production batch of 30 aircraft is being laid down, and first deliveries will be made in 1963.

PROVEN POWER

Ranging from 1,640 to 3,000-lb thrust, the Viper series of turbojets has now been flying for over 8 years and has proved itself under a wide variety of strenuous operational conditions. Over 1,000 engines have been ordered and Vipers currently power three aircraft types in service—Hunting Jet Provost, Macchi MB 326 and Jindivik target drone.

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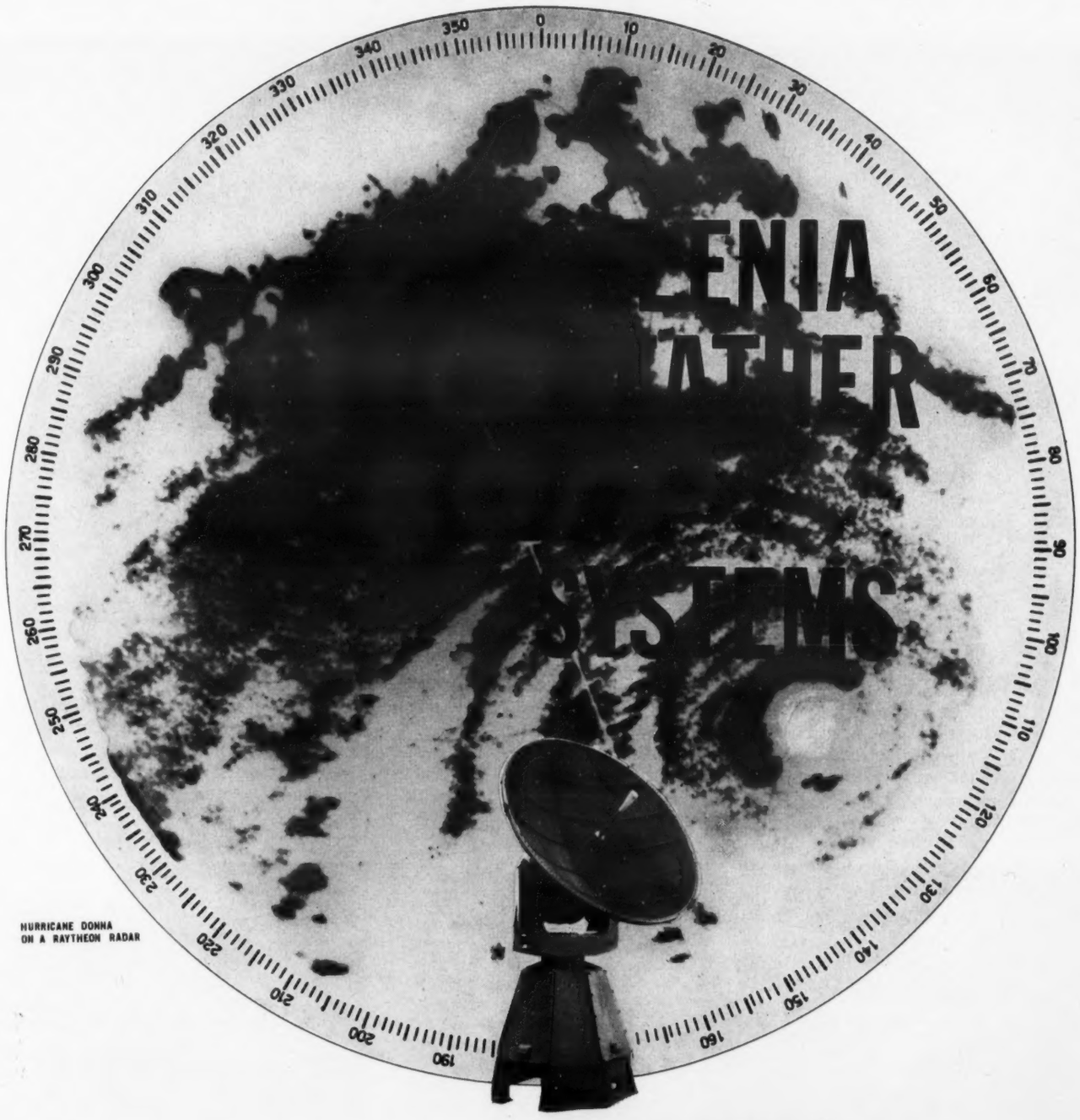

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PIPER OFFERS TWO

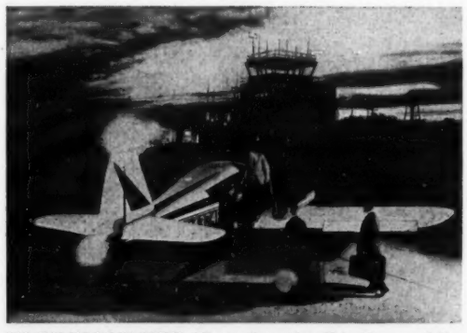
Thoroughly Proven Twin-Engine Aircraft Chosen the World Over for their Reliability and Economy

PIPER AZTEC, newest, largest, fastest of the Piper twins, cruises over 200 miles-per-hour. With a one ton useful load it can carry five passengers, complete radio and instrumentation, and full 144 gallons of fuel. It is powered by two 250 hp Lycoming engines, has very high single-engine ceiling: 10,500 feet at 4,400 pounds; 8,800 feet at 4,800 pounds gross weight. The *Aztec*'s cabin is quiet, roomy, luxuriously appointed.

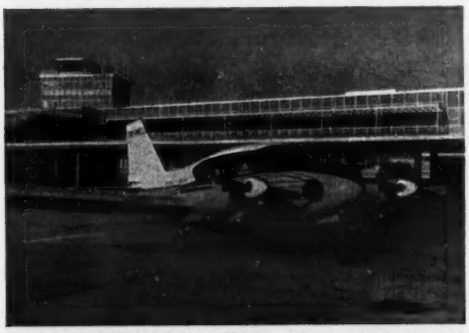
PIPER APACHE G, newest version of the world's most popular twin-engine executive aircraft, cruises over 170 mph, with range up to 1,260 miles. Carries four or five passengers. Powered by two 160 hp Lycoming engines, it is among the most economical twin-engine aircraft to own, operate, and maintain.

IN MILITARY USE Piper Aztec is in use with the United States Navy for general utility purposes.

Whether you choose the Piper *Aztec* or the Piper *Apache G*, your new Piper twin will bring you these world-famous features: Safe, easy flying characteristics; outstanding short field ability; rugged construction; big, husky landing gear with large-size nose wheel for safer operations in soft, rough fields; reliability, and minimum maintenance.



IN CIVILIAN USE Piper Apache G is the world's most widely used executive twin-engine airplane; selected by the College of Air Training, Hamble, England, for all twin-engine training of pilots destined for the airlines of the United Kingdom.



IN GOVERNMENT USE Piper Aztec was selected by the Canadian Department of Transport, which also operates five Piper Apaches for inspection duties, training, accident investigation, and transportation.

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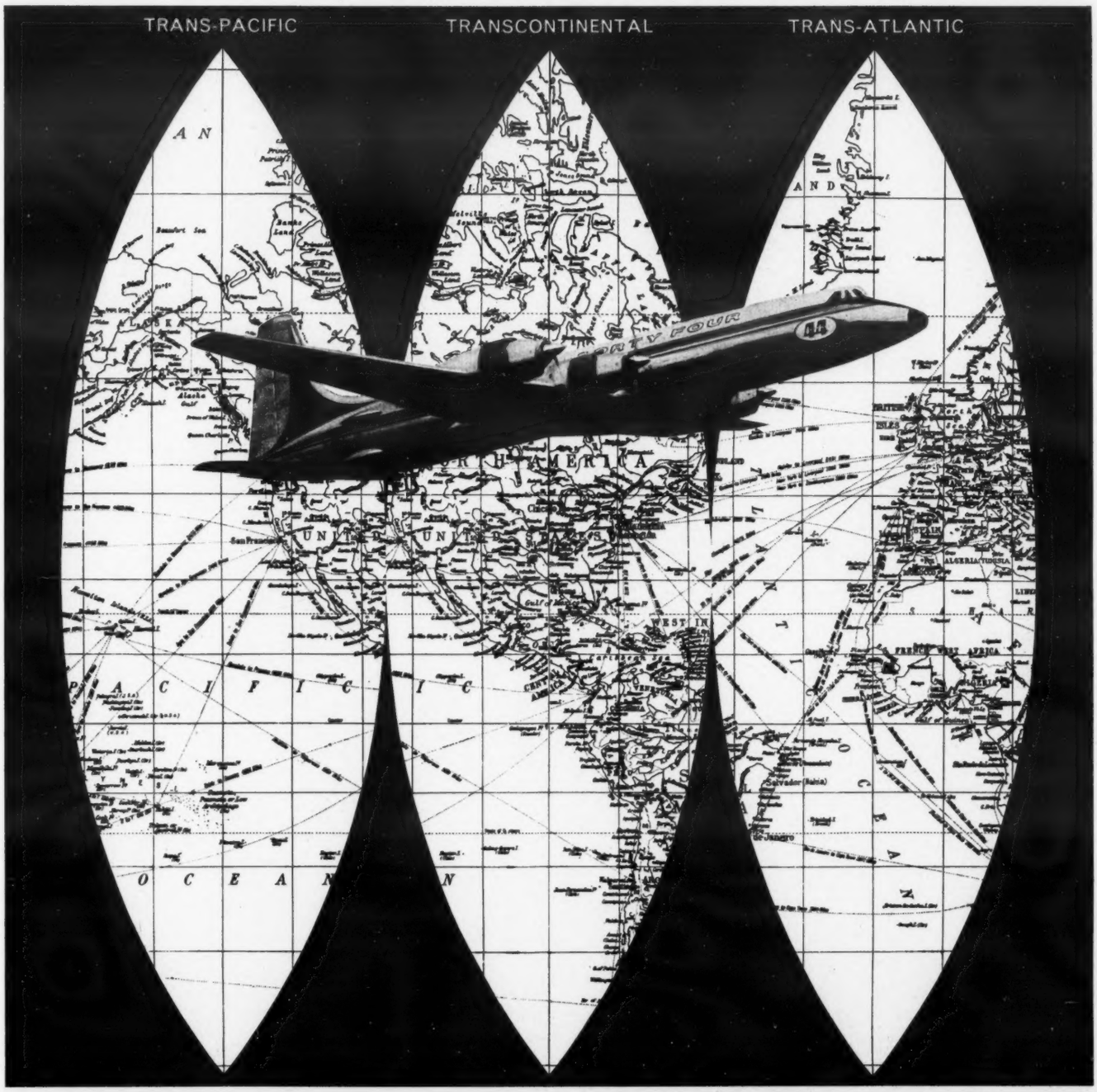
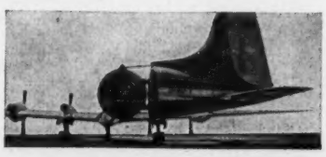


AIR CARGO SPECIALISTS* PLAN NEW FREIGHT SERVICES WITH SWING-TAIL FORTY FOUR

In the light of current developments in Air Cargo, we challenge you to consider this statement: the time has come to make a searching reappraisal of air freight operations if they are being conducted with obsolete piston-powered passenger aircraft that have been converted for cargo use. We are convinced that these aircraft, although they may still represent a multi-million dollar book investment, should now be disposed of notwithstanding current market prices, and replaced by the modern all-cargo Canadair Forty Four.

ARE YOU READY



CANADAIR
LIMITED, MONTREAL

Inevitably, the disposal will result in a "profitable loss," because it can be shown that the Forty Four is the only all-cargo aircraft able to operate at a profit, either domestically or internationally, under the new low freight rates. In a short period of time, the losses incurred on the sale of the outmoded converted equipment will be recovered by the swing-tail Forty Four. Any Canadair official would welcome the opportunity to discuss this in more detail.

*** Flying Tiger Line/Seaboard World Airlines/ Slick Airways.**

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Universal trainer

for training from the ab initio
to the advanced and
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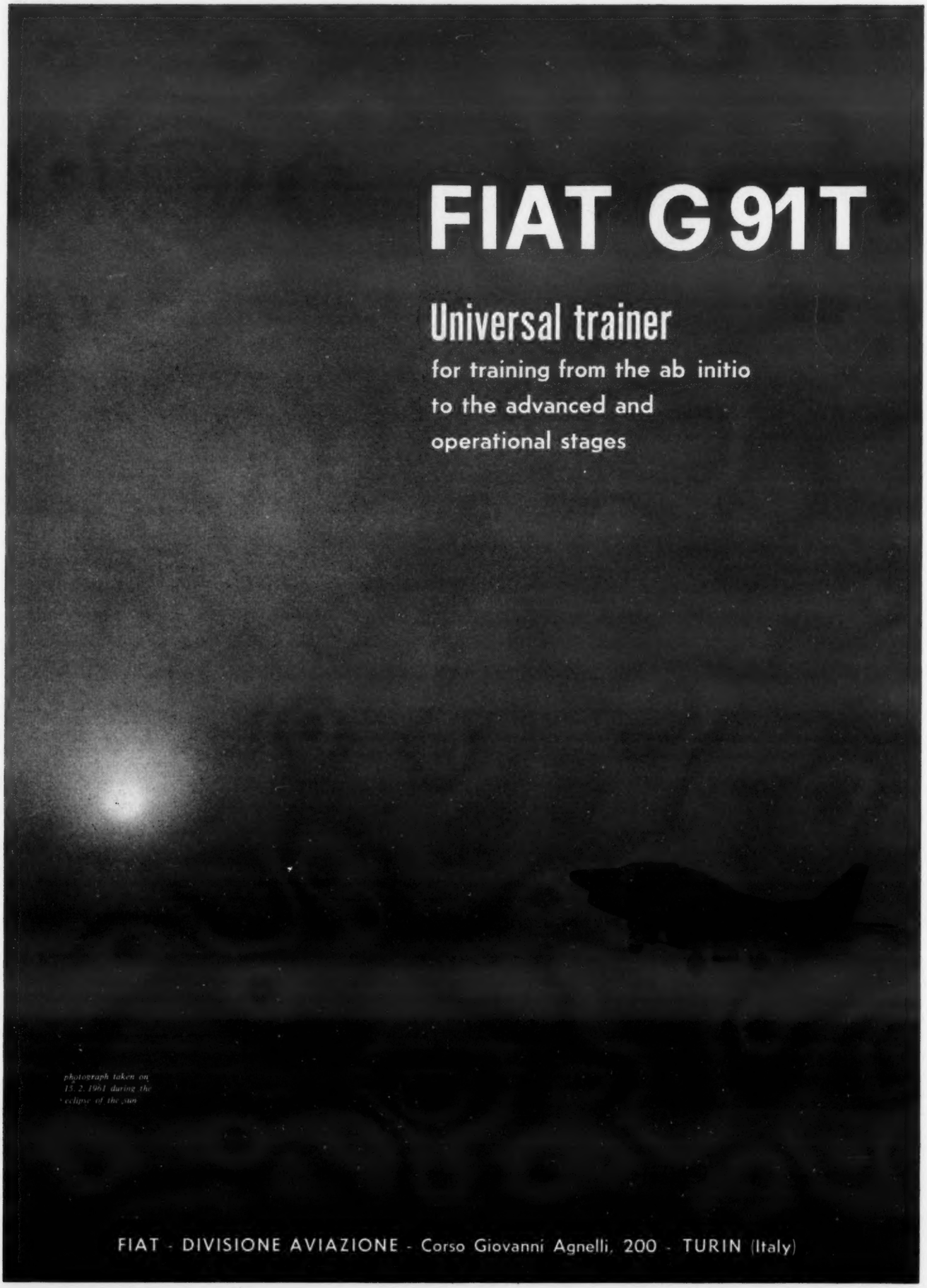

photograph taken on 15. 2. 1961 during the eclipse of the sun

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Boeing turbofan jets, fastest airliners in service

The new Boeing 707-120 and 720 "B" models, powered by Pratt & Whitney turbofan engines, are now in service. They provide higher block speeds than any other commercial jet. The 720B is the fastest airliner now in service.

The advanced design of the 707-120B and 720B is based on more than 600,000 hours of Boeing jetliner operations. The advantages of these proved-in-service features are greater schedule reliability and maintenance economy, and higher utilization.

Boeing jets, the most popular airliners in aviation history, have demonstrated outstanding passenger appeal, and greater earning power than any other jetliner. In addition, the larger cargo volume and larger cargo doors of Boeing jets offer airlines extra earning power.

These are some of the reasons why more airlines have ordered —and *re*-ordered—more jet airliners from Boeing than from any other manufacturer.

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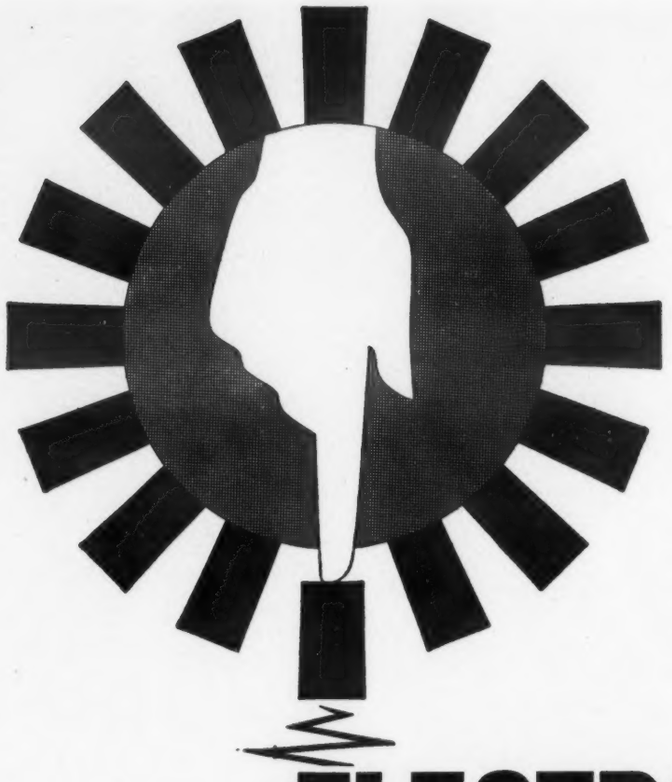

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During the Exhibition a three day symposium will be held. Executives, well versed in computer techniques, will come from a wide range of concerns—both State and private enterprises—to give registered delegates the benefit of their user knowledge and experience. All six sessions will be informal, and a highly useful exchange of ideas and information will result.
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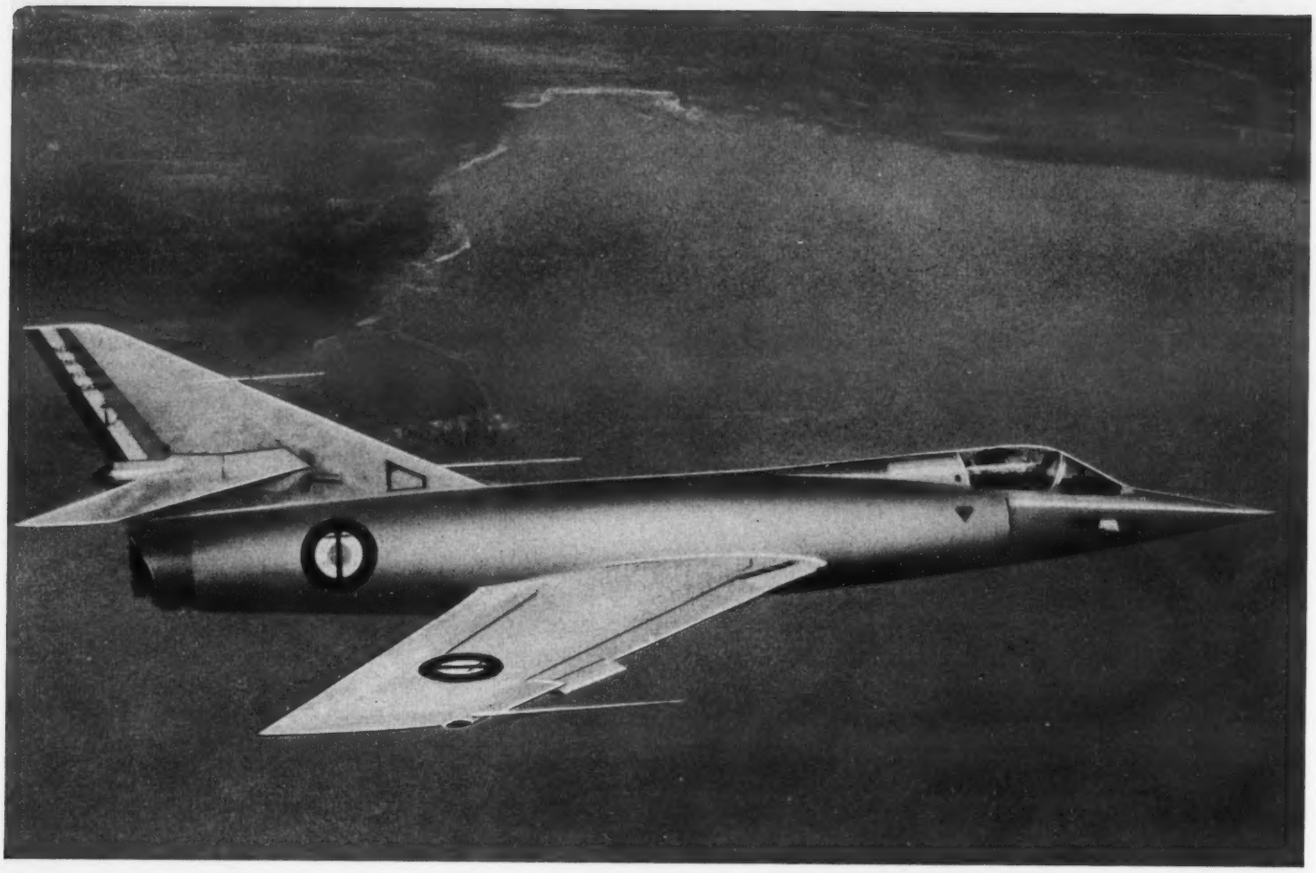

FRANCE CHOOSES SAAB BT9 TOSS BOMB COMPUTER

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SAAB – A PIONEER IN PRECISION TOSS BOMBING

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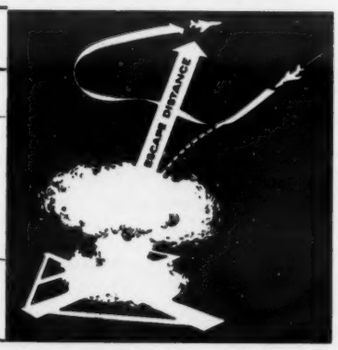
Saab BT9 Toss Bomb Computer Range of applications	
Altitude	0—6,000 m (0—20,000 ft)
Speed	M=0.5—1.0
Dive angle	10°—50°
Acceleration in pull-out	3—7 g
Maximum slant range	1,000—15,000m.(3,300—50,000ft.) (depending on speed, dive angle and bomb characteristics)



After thorough testing in France and in competition other with equipment, Aeronavale Française has ordered the SAAB BT9F Toss Bomb Computer for its carrier-based Marcel Dassault Etendard IV fighter-bombers.

The BT9 functions in principle as an analog computer. In a dive, it automatically registers altitude, dive angle, and other variables, from which it derives the correct release point. The pilot only has to direct his plane towards the target and press a pickle switch. Bomb release is automatic. With an auxiliary device, the BT9 is also suitable for firing air-to-ground rockets.

The BT9 which is the latest in a long line of SAAB toss bomb computers is produced by the Company's Jönköping Division.

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U.S. NAVY-SIKORSKY HSS-2 SPEEDS TO NEW WORLD RECORD

On May 17th at Bradley Field, Connecticut, U.S. Navy pilots in a Sikorsky HSS-2 crossed the finish marker on a three-kilometer straight line course to set a new world helicopter speed record. The speed: 310.4 kilometers an hour—41.5 kilometers an hour faster than the previous record set by a Russian Mil-6 over a 100-kilometer closed circuit in 1959. This was the first official speed test of the new generation of Sikorsky twin-turbine helicopters. The boat-hulled HSS-2, which flew in its standard configuration, soon goes into fleet service with the U.S. Navy as a key weapon in anti-submarine warfare defenses. It is the world's most advanced helicopter weapons system—and now the world's fastest helicopter as well.

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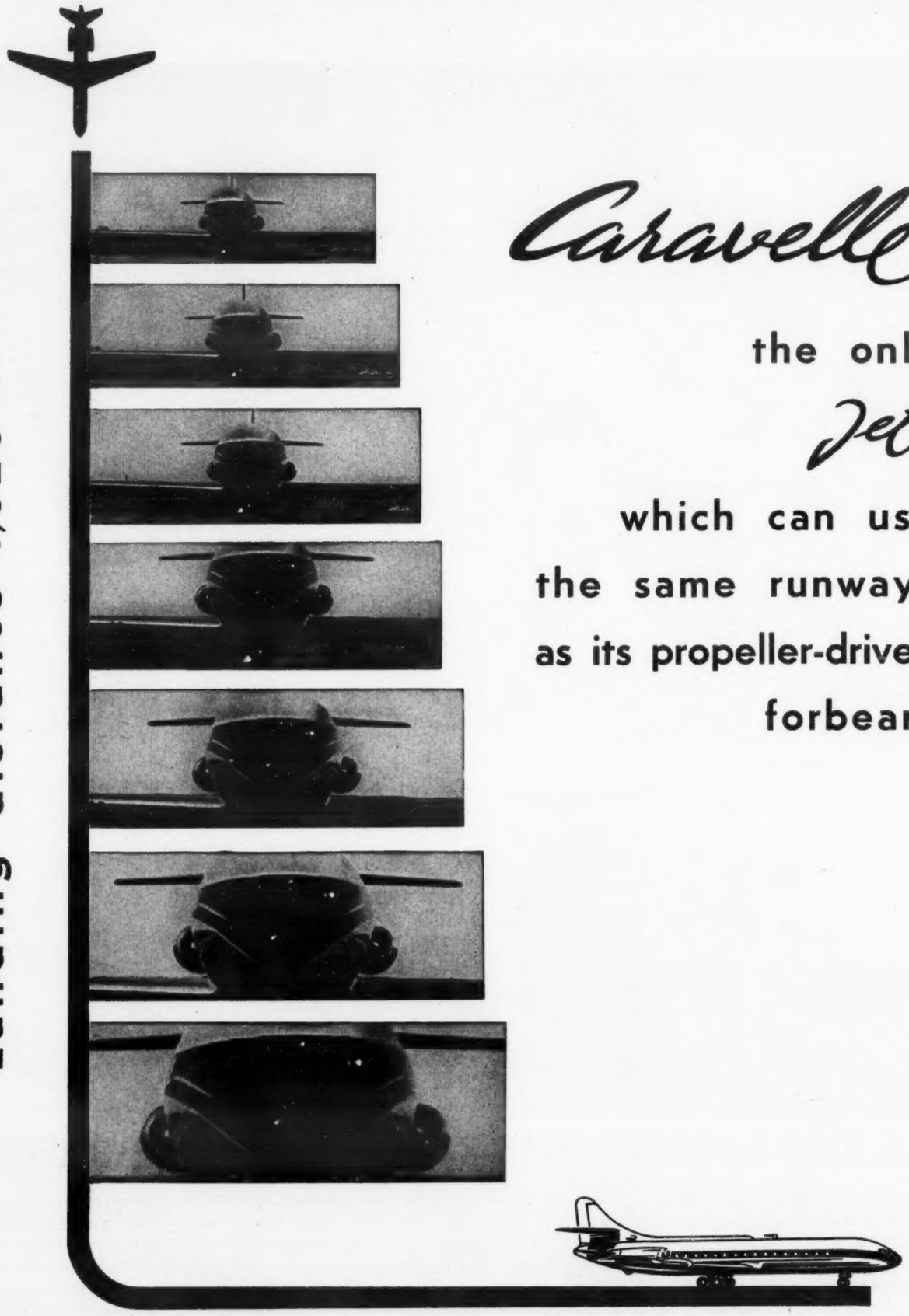

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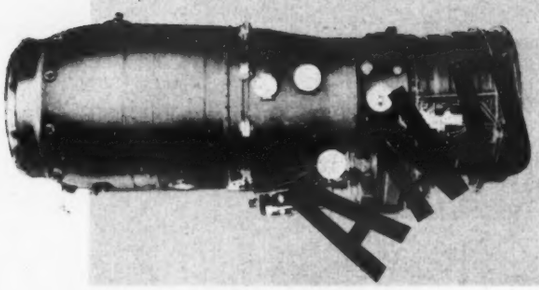
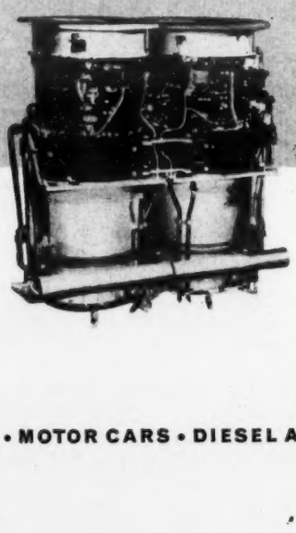


PROPULSION

POWER FOR LIFT



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Drama Without Sensation

That the Berlin crisis would flare up again was only to be expected. There was, accordingly, nothing sensational about the fact that, on the anniversary of the outbreak of the Russo-German conflict, Khruschchev mounted the tribune in general's uniform.

More surprising, perhaps, was the statement made three weeks later by Mr. K., this time in mufti, in which he made public an increase of 3.1 thousand million roubles in the Soviet budgetary allocation for the armed forces (from 9.3 to 12.4 thousand million roubles). On this occasion, he did not highlight Soviet intercontinental rockets, but announced that the disbandment of Soviet troops promised for Autumn 1961 would not take place, and went on to proclaim a drastic increase in Soviet Army manpower.

Even in making this announcement, however, the Soviet Prime Minister was still, basically, following well-trodden paths. In fact, in both East and West, the strategy based on one-sided retaliation has run into disrepute and, as is well known, to arm conventional formations costs more money than to provide a relatively small number of long-range units.

Similar voices can also be heard from the USA. Dean Acheson, the former US Secretary of State, emphatically supported the strengthening of conventional American forces in Europe. And, even more revealing, President Kennedy a few weeks ago appointed General Maxwell D. Taylor as Military Adviser to the White House. This four-star Army General, who was US Military Commandant in Berlin from 1949 to 1957, is an exponent of a balance between conventional and nuclear weapons. Two years ago, the General resigned from the Service in protest against the Eisenhower Administration strategy, based exclusively on the atom bomb, and wrote a telling book entitled "The Uncertain Trumpet."

General Taylor, is, of course, hardly so naïve as to recommend packing up the American long-range weapon units, which represent an essential element in Western security. He is, however, believed to have strongly represented to the President the necessity for revision of the early 1961 Budget Message.

As we go to press, deliberations in the Pentagon and the White House have not yet finished, but re-orientation of the procurement programme towards non-atomic weapons seems to have already been more or less decided upon. At the beginning of the year, some three-quarters of the additional credits for which Congress was asked were to go towards supporting a strategic policy based on deterrence, and only the remaining quarter were for the development of conventional forces; this ratio should now be expected to change radically.

As regards military aviation *matériel*, the Lockheed C-141 strategic jet transport was already on the procurement list of conventional armaments at the beginning of the year; this aircraft could transport large numbers of troops, as well as weapons and supplies, to threatened areas in a very short space of time. The expensive modernization programme covering the USAF's Republic F-105 single-seat combat aircraft was another pointer in the same direction; this aircraft is to be entirely re-equipped for increased all-weather missions, and provided with new armament. All in all, however, the additional credits for aircraft cut a very modest figure.

In the future, greater attention should be devoted to manned aircraft, especially the projected new multi-purpose single-seat combat aircraft for limited actions (USAF Specification TFX). As is well-known, Defense Secretary Robert S. McNamara ordered development of this relatively heavy multi-purpose aircraft, which is planned for use by all three services, to be accelerated. Meanwhile, however, some opposition against a universal aircraft of this type has become apparent. As is so often the case, the USAF and US Navy seem unable to agree on the specification. US aviation industry circles hint that the USAF is insisting on intercontinental ferry range without refuelling, which would result in a maximum takeoff weight of the order of 80,000 lb. An aircraft of this weight would, however, be too heavy to operate from a US Navy aircraft carrier, could hardly be launched by means of existing steam catapults, and certainly not handled by current deck lifts. However that may be, the USAF Tactical Air Command is the principal customer for the TFX aircraft and its wishes may well, in the end, carry the day. On the other hand, the US Navy, with the approval of the Department of Defense, is working on the development of a smaller and slower tactical aircraft for the support of ground troops, and this model would also lend itself to employment by the other services. This project, covered by Specification VAX, should lead to a robust combat aircraft with definite STOL characteristics.

In the field of bombers, it remains to be seen whether the appearance of the Soviet supersonic bomber (NATO designation *Bounder*) at Tushino, near Moscow, on the Air Force Day, will lead to renewed acceleration of the American B-70 programme. In commissioning the *Bounder*, the Russians have made it quite clear that, far from neglecting conventional aircraft, they are continuing to develop them at high pressure, regardless of their efforts to build up long-range rocket forces.

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The general rush of producers into business and tourist aircraft and the revival seen in recent years, particularly in the United States, show that there are still "peaceful" markets open to the aircraft industry, apart from the unstable armaments business. But even as regards executive aircraft the constructors are not living in a fool's paradise; as the President of Beech Aircraft, Mrs. Walter H. Beech, put it: "With competition keener than ever, efficiency, flexibility, and the ability to make every hour count are qualities essential to success in our fast-moving age." And, as can be seen from the substantial part of this issue devoted to executive aircraft, the tendency towards higher and higher speeds is becoming perceptible here too. It is particularly noteworthy that, contrary to earlier forecasts, Europe has not only become an important customer, but promises to be also an active producer of this type of aircraft.

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Nevertheless, seen in relation to the whole of the aviation and space industry, executive aircraft construction plays a relatively modest part. It is no doubt in space that the future will be decided. It remains to be seen when the race of the Great Powers for the domination of space will also encroach on the civil sector: to date, the "peaceful" probes into space do not yet serve private commercial purposes. Nor is there any lack of programmes for peaceful first-class travel to the Moon or Mars, and even the smaller industrialized countries of the world would like to reach for the stars. In Europe, vigorous differences continue to exist concerning a joint programme of research in line with the interests of all participants and, as a special article in this issue shows, agreement is for the present out of the question. ←

The *Aero Commander 680E*, a seven-seat high wing aircraft for comfortable fast travel above the bad weather.

Top Management Flies as it Pleases

Executive Aircraft for Every Purse

To avoid any misunderstanding, it may be mentioned at the outset that "executive aircraft" existed before the term was even coined: after all, practically any private aircraft can be used for business trips. In the thirties, executive aircraft construction just managed to keep alive. And when, after the World War II, American constructors of private aircraft started developing executive aircraft designed as such, this branch of the aviation industry did not look particularly promising. Even in the early fifties, when the aviation industry in general had already overcome the reverses of the immediate post-war period, private aircraft construction had to be content with very poor results—and, more often than not, with nasty losses.

Today, the picture is quite different. The last decade has seen a steep upsurge, and, in the USA alone, there are at present some 32,000 executive aircraft in use, in others words twice as many as in 1950. This figure does not include the 45,000 or so other aircraft in the "general aviation" category, such as aircraft for training, sport, agriculture and forestry, mining, taxi service, and ambulance work.

In other words, the total number of American executive aircraft is seven times the total number in regular airline service. Five years ago, the American CAA (predecessor to the Federal Aviation Agency) predicted that, by 1960, executive aircraft would be flying a total of 5,700,000 hours per year, but even this figure turned out to be too low. In fact, the number of hours flown last year was 6,300,000.

There is no need to add that this tremendous advance has had a most favourable effect on the balance sheets of the constructors engaged in this work. In 1950 the turnover in "general aviation" aircraft in the USA was $25.5 million. By 1960, it had grown to some $200 million. As was to be expected, results like this inevitably attracted into the field dozens of firms which had previously steered clear of executive aircraft construction. This was as much the case in Europe as across the Atlantic. Although the number of competitors is constantly increasing, the inner circle of executive aircraft constructors is confined to a relatively small number of concerns, and here we mean concerns who do not look at executive aircraft as an extension of their general production programme, but as their *raison d'être*. And it is interesting to see how the traditional specialists in this branch of aircraft production view this or that new technical or economic trend, how they associate themselves with certain "fashions," but oppose or pursue a wait-and-see policy in relation to others.

In the USA, there are in fact four firms—Aero Commander Inc., Beech Aircraft Corp., Cessna Aircraft Co., and Piper Aircraft Corp.—who between them account for over 95 percent of the

There is ample room in the Beech *Twin-Bonanza* for seven occupants and their luggage.

total turnover in executive aircraft. And this is not to say that these typically executive aircraft constructors have been turning down military orders or sub-contracts offered by the aviation industry. Cessna is, for example, building the T-37 jet trainer for the US Air Force, delivering its 310 model as a military liaison aircraft, participating in the B-52 programme by supplying tailplanes, and delivering *Skyhook* helicopters to the US Air Force (under the designation CH-1C) and recently to the US Navy also. In 1960, military equipment supplied by this firm amounted to some $27 million. Beech Aircraft Corporation's military order book is also very healthy. To illustrate the trend of the past ten years, we can do no better than look at the example of Piper Aircraft Corporation, whose results over the past decade are given below.

Some Piper Aircraft Corp. Results (1950/1961)

Financial Year ending Sept. 30th	Sales ($ million)	Profit ($ million)	Profit per share ($)	Dividend ($)	Highs and Lows (Piper Aircraft Shares)	
1961	—	—	—	1.00	58⅛	42⅝
1960	40.21	3.52	3.29	1.05[1]	73	43¾
1959	34.26	2.78	3.00	1.00	53¾	20¼
1958	27.11	2.19	2.36	1.00	24½	14
1957	26.62	2.72	2.94	1.00[1]	21½	11¾
1956	25.08	2.55	2.88	0.80	18¾	12⅛
1955	16.81	1.40	1.62	0.40	12¾	5¾
1954	11.42	0.43	0.46	0.05	6	2
1953	12.48	0.40	0.42	0.0	3¼	1⅛
1952	9.91	0.40	0.41	0.0	3⅜	2⅛
1951	5.84	0.54	0.58	0.0	3¾	2⅛
1950	3.91	0.18(d)	0.27(d)	0.0	3¾	1⅜

(d) = deficit [1] = + 5 % bonus shares

Europe Some Lengths Behind

The four concerns mentioned are the leaders of this branch of industry in America, and the USA in turn for the time being occupies a leading position in the world executive aircraft market. Although Europe has pulled up relatively quickly in the last few years—as of May 1961, de Havilland had delivered over 500 *Doves* and some 140 *Herons*, with comparable successes to the credit of Morane-Saulnier in France, Piaggio in Italy and Dornier in Western Germany—she is still nowhere near America in respect of the scale of production or number of executive aircraft in use. In 1960, Cessna sold 3,720 aircraft, Piper 2,313, and Beech 962, and whereas 32,000 executive aircraft are, as already mentioned, in service in the USA, a British estimate published a few weeks ago puts the total British "executive fleet" at barely 100 machines, belonging to some 80 commercial houses.

There are, however, certain signs that British interest in this direction is awakening. For instance, a Business Aircraft Users Association was formed in London in May of this year, with the main object of pressing for the establishment of airfields in the neighbourhood of large towns. Again, the Air League of the British Empire recently published a comprehensive report on the state of British executive flying, in which one of the points stressed was the need for this type of aircraft, British firms having in 1960 ordered over 60 executive aircraft from producers abroad. There is also the move of the Pressed Steel Company Ltd., which, in Autumn 1960, established a new subsidiary for the production of private aircraft, namely British Executive and General Aviation Ltd. (BEAGLE), with Peter Masefield as Managing Director.

France's advantage in the executive aircraft business is that her airframe constructors have an extremely active manufacturer of small turbines on which to rely, namely Turboméca. For the rest, the export successes of Morane-Saulnier (over 90 *Paris*, as well as no less than 500 *Rallye Clubs* and *Super Rallyes*, ordered by 20 countries up to mid, 1961) speak for themselves. Eastern Europe also shows some promise in the field of touring aircraft. The Czechoslovakian Foreign Trade Organisation "Omnipol," for instance, is keenly publicising its *Morava* L200, the "aircraft for those who cannot be dependent on airline schedules."

From the Small Aircraft to the Executive "Airliner"

Having sketched in the general economic background, let us now turn to the aircraft themselves, of which there is a very wide range. Indeed, there is at least as much difference between business aircraft at each end of the scale as between, say, a bubble car and a limousine.

At present, the small and very small types are in the large majority and the piston engine is predominant. Very recently, however, a trend towards larger, faster, and more comfortable executive aircraft has become discernible.

The average speed of piston-engined models lies around 190 m.p.h., at which level the technical possibilities of this type of powerplant are nearly exhausted and every further increase in speed must be bought at a considerable extra cost in engine power. The Beech *Travel Air* and the LAS *Super* 26 are good examples of this; whereas the former achieves a speed of 194 m.p.h. with two

If desired, the seats of the Cessna *Skyknight* can be supplied with gilt leather—an optional extra, of course.

Even the small Cessna 310 F is remarkably comfortable. Its sofa can be used as a seat, or for reclining.

The spacious, pressurized cabin of the Grumman *Gulfstream* twin-engined turboprop, which can be equipped as a conference room.

In the studied interior of the Beech *Queen Air*, which, needless to say, includes a buffet and bar, business journeys are always pleasant, even if the flight is lengthy (1,200 miles can be covered in some 8 hours).

The 1961 version of the seven-seat Beechcraft J50 *Twin-Bonanza* is fitted with two Lycoming supercharged engines with fuel injection, and can travel at 15,200 ft.

The five-seat Beech *Baron*. On the basis of 500 flying hours or 100,000 miles per annum utilization, operational costs, as quoted by the producer, are $23.46 per hour flown and total cost per seat mile 4.2 cents.

So far over 7,000 Beech 18s have been produced in various civil and military versions. Our picture shows the new *Super G18* eight-seat version with panoramic windows.

The two-engined Beech *Queen Air*, a new member of the Beech family, is normally supplied in a seven-seat version, though up to 9 persons can be carried. Maximum speed is 239 m.p.h.

180 h.p. engines the latter needs two of 2,400 h.p. in order to attain a speed of 375 m.p.h. For many purposes, the high cost in horsepower may seem no longer worthwhile, and this has led designers to concentrate more on improving fuel consumption (injection systems) and bettering altitude performance (supercharged engine) than on increasing engine output.

On the other hand, by installing small or medium turboprops, an increase in cruising speed to an average of 310 m.p.h. can be secured without an excessive effort in terms of horsepower, and this is a very respectable gain, even after taking into account the considerable difference in price between the two types of engine. On top of this, there is the advantage of smaller dimensions and reduced weight, which in turn also favourably affect flight performance. Apart from the conversion of piston-engined aircraft, as undertaken by SFERMA/Beech for instance, a number of aircraft constructors are planning to instal turboprops in their new executive models from the word go. This is true not only of the French, who need not look further than Turboméca as a "home producer" of engines of the desired power class but also, for instance, of the Beech Aircraft Corp., which is working on a turboprop aircraft of the *Queen Air* class. Apparently, however, neither Piper nor Cessna are at present planning the construction of turboprop executive aircraft. Despite the undoubted successes of the turbo-engine industry, the constructors of business aircraft have still some inhibitions about the turboprop, although it is not entirely clear on what grounds. It is conceivable that certain producers fight shy of the extra costs of the engines, pressurized cabin, and noise and vibration absorption, which are inevitably associated with the turboprop. It is also possible that, before starting on new turboprop designs, they prefer to await further developments in the field of bypass jet engines, which undoubtedly meet the general demand for increased speed even better than turboprops.

List Prices* of Some Executive Aircraft

	U.S. Dollars
Piston-engined Aircraft	
Piper Apache G.	46,000
Beech Travel Air	50,000
Dornier Do 28	52,000
Piaggio P. 136	52,000
De Havilland Australia Drover Mk.4	56,000
Beech Baron	58,000
Piper Aztec	59,000
Cessna 310 F	63,000
Cessna Skyknight	68,000
De Havilland Dove 8	100,000
Beech Twin-Bonanza (J50)	100,000
Aero Commander 680 F	113,000
Beech Queen Air	126,000
Beech Super G18S	132,000
Aero Commander 680 FP	158,000
Turboprop-engined Aircraft	
Potez 840	360,000
Dassault Communauté	500,000
Grumman Gulfstream	900,000
Jet-Engined Aircraft	
Procaer F.400 Cobra	81,000
SAAC.23	325,000
Israel Aircraft B.101C	350,000
Aero Commander Jet Commander	555,000
North American Sabreliner	900,000
Lockheed JetStar	1,300,000

* The prices shown are to a large extent based on information from the constructors, and are rounded off to the nearest $1,000. As the prices given are subject to considerable variation, according to the optional equipment selected, they should be treated with discretion.

Executive Aircraft

The most noteworthy fact in the recent history of the executive aircraft is the constructors' growing enthusiasm for the fast jet-powered machine.

The last few months have seen a succession of announcements of new executive jets. The six well-known developments of Lockheed, North American, Morane-Saulnier, Cessna, Procaer and Israel Aircraft, which have been in production for quite a long time, in some cases for years, are now no longer alone. Recently, eight more challengers have entered the lists. These are the de Havilland DH.125 *Jet Dragon* (Great Britain); the Aerocommander 1121 *Jet Commander* and the McDonnell 220 (USA); the SAAC.23 *Execujet* (USA/Switzerland); the Douglas/Piaggio PD-808 (USA/Italy); the Potez/Heinkel CM.191 (France/Germany); the Saab 105 (Sweden); and the Hispano Aviación H.A.230 *Saeta Voyager* (Spain).

In increasing speed, the producers are of course motivated by the needs of their customers, who do not want their timings to lag too far behind those of regular jet airlines. Here, for instance, are some of the block times quoted by Lockheed, for a round-the-world trip in the four-engined *JetStar:* New York–Gander, 2 hrs 2 mins; Gander–London, 4 hrs 39 mins; London–Paris, 29 mins; Paris–Rome, 1 hr 19 mins; Rome–Beirut, 2 hrs 31 mins. Aerocommander's publicity stresses that New York and San Francisco lie only three hours away from Kansas City by *Jet Commander*. And in the prospectus for the executive version of the *Caravelle,* Sud-Aviation points out that the passenger puts 250 miles behind him in the time it takes to smoke a cigar.

On an average, executive jets develop speeds of around 465 m.p.h. In order, however, to increase range and reduce fuel consumption, a start has very recently been made in equipping business aircraft with bypass engines, the pioneer being Saab, whose 105 is to be fitted with Turboméca engines. It is rather astonishing that Saab is, so far, the only producer to exploit the bypass engine, although constructors are unanimous about its capabilities.

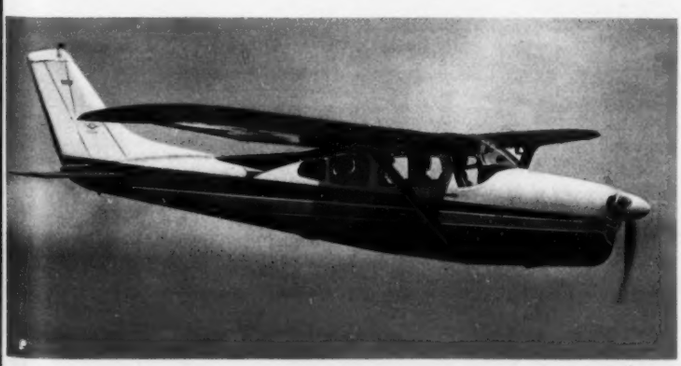
What are, then, the prospects for an executive jet? There is no doubt that many users will be tempted to go over to jets by the gain in time. On the other hand, it would be unrealistic to overlook certain difficulties which must be reckoned with in marketing an aircraft of this type.

First, the sales price. As can be seen from our tables, jet prices go up to $1,300,000, which is beyond the reach of all save very substantial concerns. Thus we find that the 26 firms who have

In March 1961, Max Conrad, the well-known sports pilot, made a round-the-world flight in a Piper *Aztec*. The 26,850-mile journey took 8¾ days.

The elegant Piper *Comanche,* fitted with a Lycoming 250 h.p. engine, can reach a maximum cruising speed of some 180 m.p.h.; with 4 people and baggage, range is in excess of 1,100 miles.

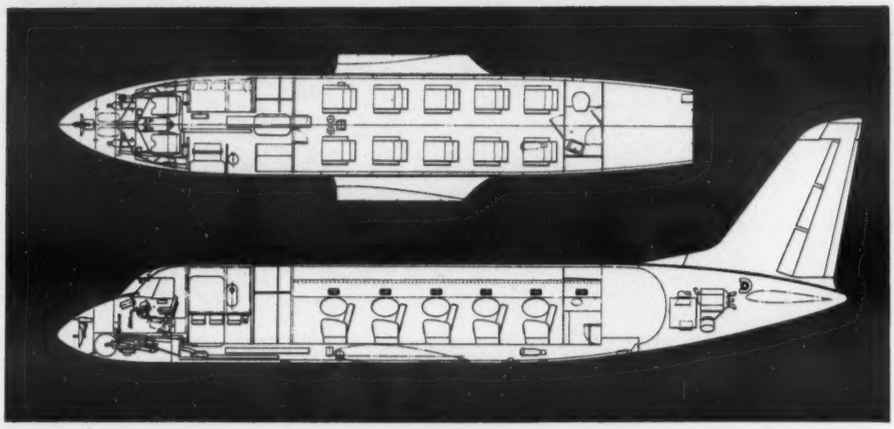
A few months ago, the Piper *Cherokee* four-seat tourer was demonstrated publicly. It is fitted with a 160 h.p. Lycoming engine and can be bought for $9,995. This all-metal, low-wing monoplane, which is simple in operation and maintenance, marks a new standard in the light tourist and executive aircraft category. The components are built mainly at Piper's new facility at Vero Beach, Florida.



There is considerable interest, both in USA and abroad, in the Cessna 210, a fast four-seat tourer offering an excellent view, comfortable access, generous luggage room, and copious instrumentation. The retractable undercarriage is unusual for a high-wing monoplane.

In the *Skymaster,* Cessna has found their own distinct solution to the twin-engine requirement. First deliveries are expected in 1962, and the prototype shown here is at present undergoing thorough flight testing.

The Cessna 320 *Skyknight,* confusingly similar to the Cessna 310, has, according to the manufacturer, successfully flown over the 14,100 ft summit of Pikes Peak in the Rockies, with over 3,000 ft to spare. The *Skyknight* is a typical example of the trend towards a better view for the passengers by means of additional cabin windows.



Layout of the cabin of the ten-seat version of the Grumman *Gulfstream*. The usable cabin length of the passenger version is 32.7 ft and 19 passengers can be carried. The air pressurization and conditioning systems can be seen at the rear of the fuselage and the radar forward. The *Gulfstream* is certificated for cruising at altitudes of up to 30,000 ft and two Rolls-Royce *Dart 529* engines (2,105 e.h.p. each) give it a maximum cruising speed of 356 m.p.h.

ordered the Lockheed *JetStar* are big international names, such as the Hercules Powder Company of the United States, Continental Can and Pratt and Whitney in the USA, Krupp in Germany, and so on. Price apart, the airport problem is just as acute as it is in the case of jet airliners, for takeoff runs of 2,650, 3,000 and even 3,300 ft are hardly a passport to appreciably more airports than are open to jet airliners. The same is true of the noise problem, since those living in the vicinity of airports do not take any more kindly to executive jets than to jet airliners. Another serious difficulty is the shortage of first-class pilots, since top management obviously do not intend to let themselves in for "airborne adventures." In their attractive sales brochures, the makers of piston-engine executive aircraft offer their customers free pilot training, but this can hardly be applied to jets.

Safety and Comfort

Whether the engine in question is piston, turboprop, or jet, the constructors of executive aircraft spare neither trouble nor expense to provide their final products with everything in the way of cabin layout and equipment which can be used as a selling point.

In even the smallest types, the cabin sound proofing is of a high standard; conferences can be conducted and files perused without interference. The secretary has her special place, the managing director a private compartment where he can hold discussions with his staff or with customers, there is a dining compartment where he can invite guests, and a bar. If the flight takes place at night, the seats can be converted to beds. Telephone communication with head office is, of course, readily available. And hotel accommodation at intermediate stops can, if necessary, be dispensed with.

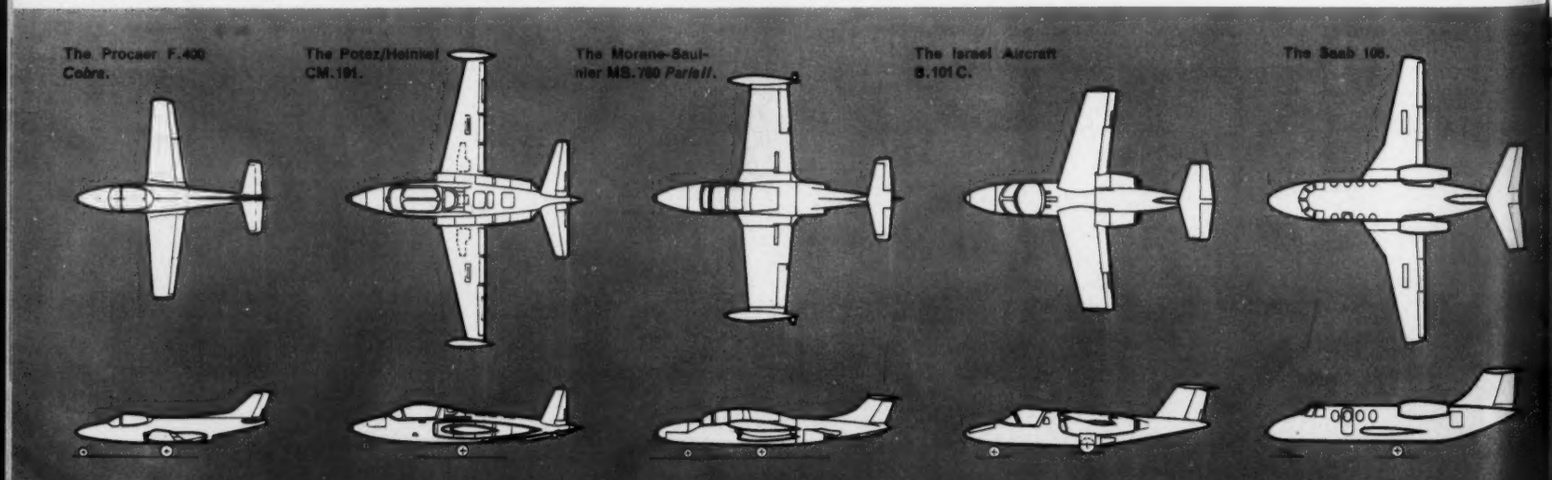
The cockpit of a modern executive aircraft closely resembles that of an airliner. Most types have a radio navigation system. The cost of complete all-weather equipment can of course amount to as much as $28,000*.

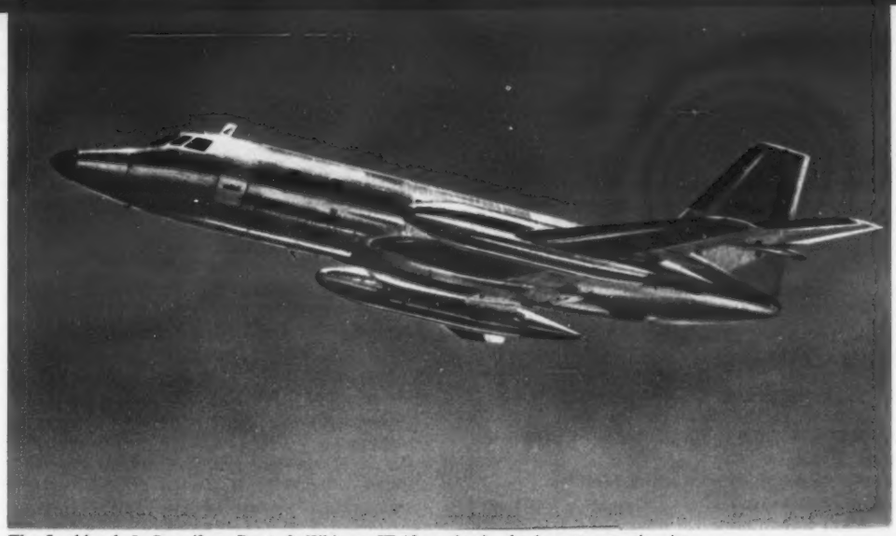
The Piper *Aztec* is an example of an executive aircraft well equipped with radio and radio navigation aids. Its *Super-Custom* version (price $58,060 ex works), is supplied with the following equipment for radio communications and also for navigation: two NARCO MKV VHF transmitter/receivers (90-channel transmitter, 118 to 126.9 Mc/s; 190-channel crystal-controlled receiver, 108 to 126.9 Mc/s); one NARCO CS-3A VOR/ILS localizer indicator with NARCO VOA-3A omni-converter, used in conjunction with the NARCO Mark V; one NARCO Mark VI VHF 90-channel crystal-controlled receiver (108 to 126.9 Mc/s) with VOR/ILS localizer indicator; one Motorola ADF-T12 radio compass (transistorized, 190 to 430 Kc/s, 480 to 1,025 Kc/s, and 1,025 to 1,725 Kc/s); and one NARCO MBT marker receiver (75 Mc/s) with light indicator for fan markers, Z-markers and outer and middle markers (ILS). Equivalent equipment by Collins, Sunair, or ARC can be supplied in lieu of the NARCO and Motorola items.

Given equipment of this kind, navigation should present no difficulties, and the pilot's task is considerably lightened.

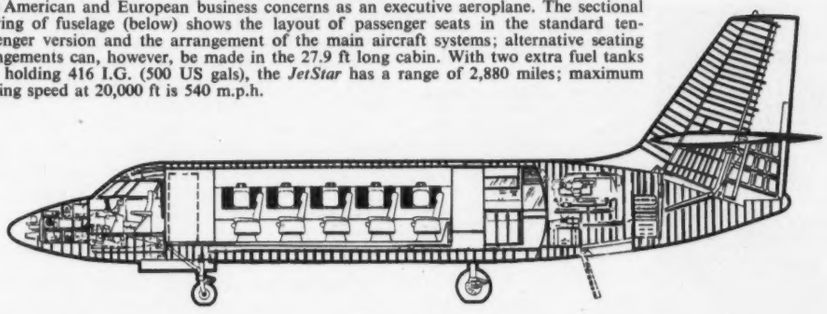
So much for navigation. In order, however, to simplify control as far as possible, Piper designed

* The following concerns are among those supplying radio and radio navigation equipment for executive aircraft: Aircraft Radio Corporation (ARC), Boonton, New Jersey; Bendix International Division, New York; Collins Radio Company, Cedar Rapids, Iowa; Dare Inc., Troy, Ohio; The Decca Navigator Company Ltd., London; Airborne Radar and Radio Division of Elliott Brothers (London) Ltd., London; Marconi's Wireless Telegraph Company Ltd., Chelmsford, England; Motorola Aviation Electronics Inc., Santa Monica, California; National Aeronautical Corporation (NARCO), Fort Washington, Pennsylvania; The Plessey Company Ltd., Ilford, England; Radio Corporation of America (RCA), Los Angeles; Sunair Electronics Inc., Fort Lauderdale, Florida.





The Lockheed *JetStar* (four Pratt & Whitney JT-12 engines), the largest executive jet so far, was originally designed to fulfil a military requirement, namely that of USAF specification UC/X. It is used by the MATS Airways and Air Communication Service for the electronic monitoring of ground radio and navigation systems, and has been offered to various air forces as a trainer for special electronic tasks. It has also been ordered by some large American and European business concerns as an executive aeroplane. The sectional drawing of fuselage (below) shows the layout of passenger seats in the standard ten-passenger version and the arrangement of the main aircraft systems; alternative seating arrangements can, however, be made in the 27.9 ft long cabin. With two extra fuel tanks each holding 416 I.G. (500 US gals), the *JetStar* has a range of 2,880 miles; maximum cruising speed at 20,000 ft is 540 m.p.h.



the Autoflite version (supplement $800). In addition to the equipment listed above, this version is fitted with a lightweight transistorized flight regulator, the "Auto-Control," which automatically holds the course set or brings the aircraft on to new course. The Auto-Control equipment is linked to an artificial horizon and to a directional gyro modified for the purpose.

Piper's Altimatic Pilot promises still better results, and is listed at $1,995. This three-dimensional autopilot automatically brings the aircraft on to any pre-selected course, allows it to climb or descend to the desired altitude, and then holds it there.

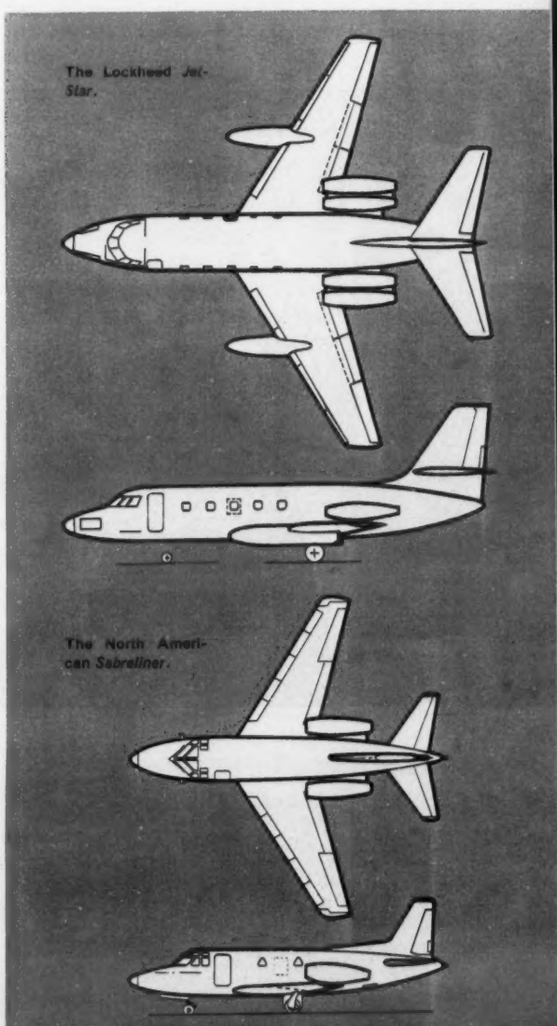
A further press-button navigation instrument, the LIFE (Lear Integrated Flight Equipment), was fully described in *Interavia* 10/1960, page 1,294. Weather radars for executive aircraft are also available, and these enable the pilot to avoid areas of turbulence.

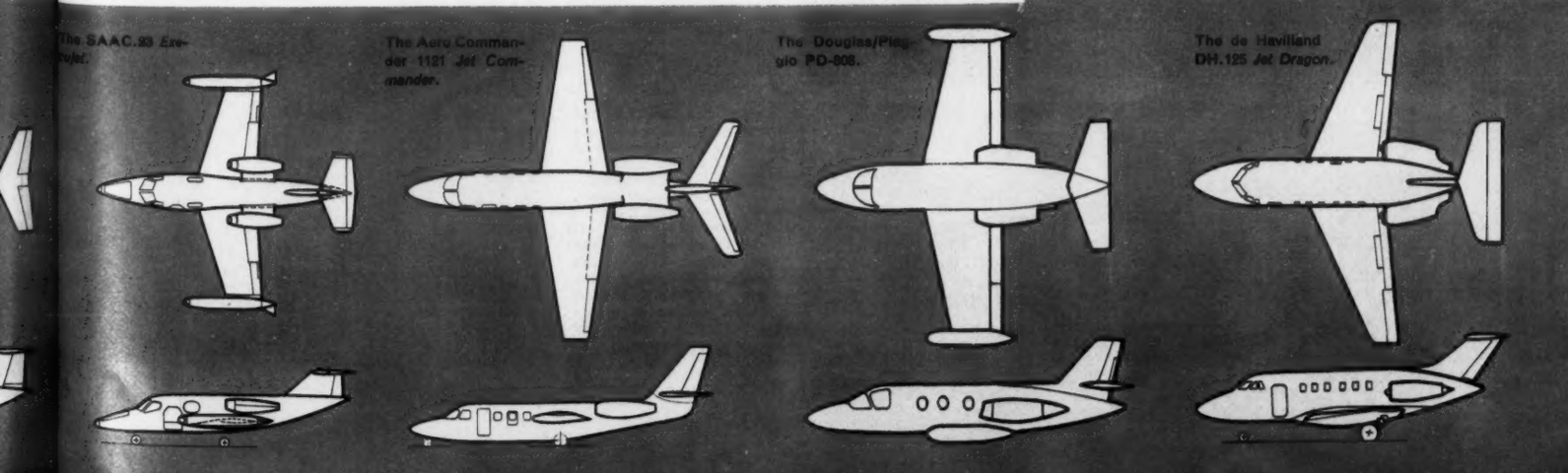
It is impossible even to touch on all the latest improvements, such as panoramic windows, de-icing systems, retractable landing floodlights, and the very many other improvements which characterize modern executive aircraft and make for increased safety, comfort, and efficiency.

The Youngest Generation

The features and performance of the executive aircraft (piston, turboprop, and jet) at present in use or under development, are set out in our table. This, however, includes neither single-engined models, helicopters, nor passenger transports converted to executive aircraft, all of which have had to be omitted for reasons of space. However, in order to give some pointers to the very latest trends in development, we shall single out a number of types which have not yet been discussed in earlier numbers of *Interavia*.

In the piston-engined category, there is in the first place the Cessna *Skymaster*, which successfully flew for the first time on February 28th, 1961. According to the pictures of the prototype which have so far appeared, this is a braced high wing aircraft with fixed tricycle landing gear. Unlike the present usual layout, the two Continental engines are located in front of, and behind, the four-place cabin. According to reports, Cessna is currently working on the 410, a two-engined aircraft in the 8,000 lb class, which is understood to be designed for up to ten seats and a speed of about 250 m.p.h. Aero Commander is preparing to produce a pressurized 680F with Lycoming 500 h.p. eight-cylinder engines. Whether the distinctive design of Rhein Flugzeugbau GmbH for its RF1, with ducted propeller, can make headway remains to be seen. The Max Holste *Broussard Major*, publicly exhibited for the first time at the Paris Salon, does not, on the other hand, depart from convention



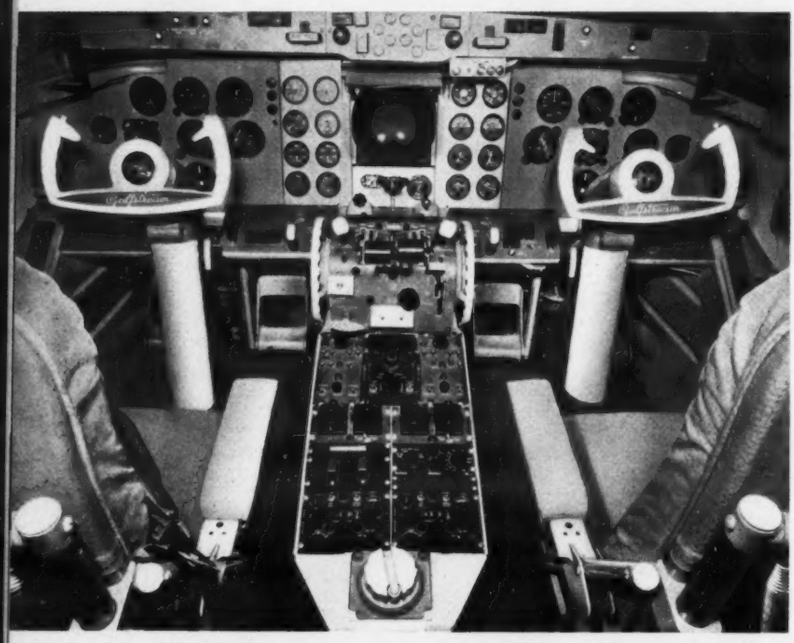


and is, for all practical purposes, a smaller *Super Broussard* with fixed tricycle undercarriage.

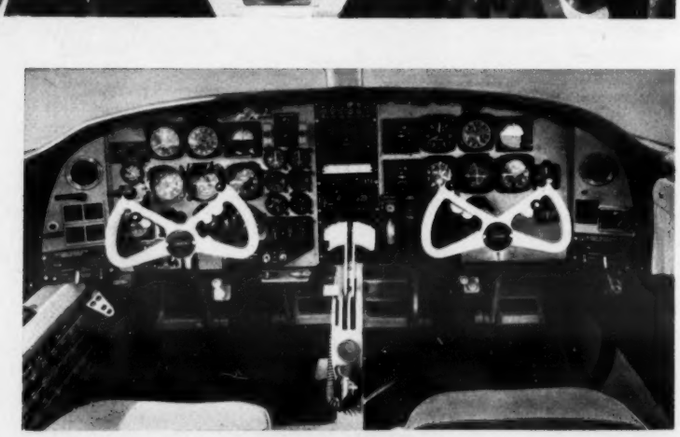
In the turboprop class, mention should be made of the *Spirale III*, developed by Sud-Aviation and Dassault as a military transport, which could be offered in a civil version for business travel in place of the *Communauté A*1. The *Spirale III* is equipped with two Turboméca *Turmo IIID* engines, each 1,300 h.p., and, at a takeoff weight of 20,950 lb, manages with a take-off run of barely 1,000 ft (over a 50 ft obstacle). Maximum cruising speed of this aircraft is quoted as 281 m.p.h., and range with a payload of 3,300 lb as about 931 miles.

The possibility of replacing piston engines by turboprops will perhaps be utilized by more firms, now that SFERMA seems to be satisfied with the conversion of the Beech 18, *Travel Air*, and *Baron*. The *Marquis*, derived from the *Baron*, and equipped with two *Astazou IIA* engines, attains a cruising speed of 267 m.p.h., as against 220 m.p.h. for the original model. As compared with the *Super G*185, its PD.183 derivative shows a gain of about 60 m.p.h. and, after "surgery" the *Turbo-Travel Air* was as much as 97 m.p.h. faster than the piston-engine model.

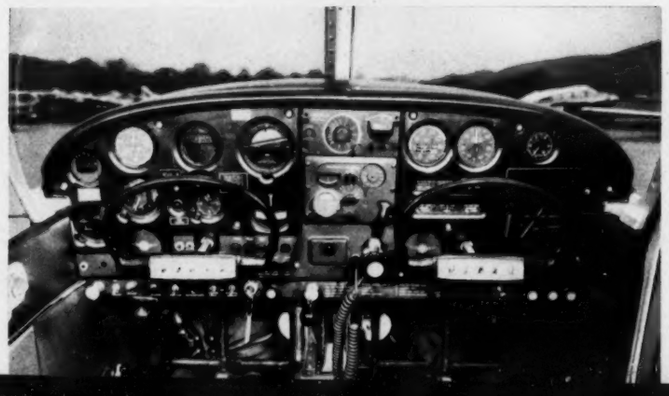
The vast majority of the new models are in the jet category and are predominantly of European origin. Morane-Saulnier, whose *Paris* is one of the first jets to have been offerd for business travel, had sold over 130 machines by the Spring of this year. The producer has not, however, rested on his laurels, but is already offering a version III of the *Paris*, which is now a five-seat model with a maximum speed of 445 m.p.h. and maximum range of 1,370 miles. Potez and Heinkel have developed the CM.191 from the time-tested *Magister* (see the report in *Interavia* 5/1961, page 555).



The cockpit of the Grumman *Gulfstream* executive aircraft is practically the same as that of a turboprop airliner. The instruments are clearly displayed and some of them, such as the airspeed indicators, the sensitive altimeters, and the rate of climb indicators, are duplicated, at each position, for the pilot and co-pilot. The screen of the airborne radar can be seen in the centre above the control pedestal.



In the Cessna 407 jet touring aircraft, the instruments for pilot and co-pilot are, with certain exceptions, basically identical. The instrument panel taken as a whole is nearly as complete as it is in the considerably larger *Gulfstream*.



Pleasing simplicity is the keynote of the instrument panel on the single-engined Piper *Cherokee*. Left: the flight monitoring equipment. Centre: the radio panel. Right: the engine monitoring instruments and, extreme right, a large glove compartment. The radio equipment includes a Piper Auto Nav Radiocompass (above), and Narco "Superhomer"; VHF radio and navigation equipment (below).

In Great Britain, de Havilland is following up the *Dove* and *Heron* with the *Dragon* (cf. *Interavia* 5/1961, page 554) and, in Italy, Procaer is hoping to gain a foothold in the market with the four-seat F.600, a further development of the *Cobra*. This aircraft, with its two jet engines of 660 lb thrust, is understood to have a maximum speed of 390 m.p.h. and a flight endurance of three hours. Takeoff weight is quoted at 5,510 lb. In *Interavia* 5/1961 (page 555), we reported on the PD-808, which is to be built by Piaggio on the basis of a Douglas design.

There is as yet not much to be learnt concerning the six-seat HA.230 *Saeta Voyager*, which Hispano Aviación has under development. Two *Turboméca Marboré II* engines of 880 lb thrust each are said to be intended as powerplant. Switzerland is participating in this race through the Swiss American Aviation Corporation, and intends to build the SAAC.23 *Execujet* (cf. *Interavia* 5/1961, page 676).

The latest new design to come out of Europe is the Swedish Saab 105, to which an article in the present issue of *Interavia* is devoted. The *Jet Commander*, the new jet executive aircraft of Aero Commander Inc., is also the subject of a contribution in this number.

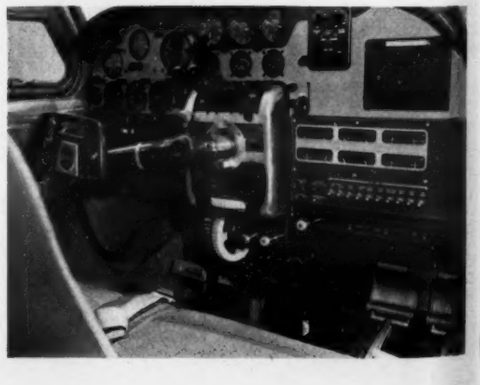
Cessna also intends to market a new jet executive aircraft, derived from the T-37, in about two years' time. This four-seat model is expected to have a cruising speed of about 500 m.p.h. and a range of some 1,200 miles.

Optimism all along the line

Although the year 1961 started with a small blemish—in the first two months, sales of private aircraft in the USA went down to about 1,200 as compared with 1,500 in the same period of 1960—those concerned remain extremely optimistic. Both official authorities and constructors estimate that, in 1970, a total of some 60,000 business aircraft will be operating, i.e. double the 1961 figure. Numerous arguments are advanced in support of this confident optimism, amongst them the following:—

- Regular airlines use barely 600 of the 6,000 or so existing American airfields, and there is thus a strong incentive to operate executive aircraft in the future.
- Recent market research has shown that only 12 percent of the 3,000 most important industrial and commercial enterprises in the USA at present dispose of their own executive aircraft, from which it can be inferred that 88 percent of the market is still untapped. Apart from these 3,000 concerns, there are certainly tens of thou-

The cockpit of the Beech *Travelair* differs in some respects from those of other executive models. Points of difference include the centrally located control column with swivelling arm for the control wheel; engine throttle, propeller-pitch control, and mixture control on the central console; flight and engine monitoring instruments on the left half of the instrument panel; and rudder control pedals which can be folded forwards to give leg room to a passenger occupying the co-pilot's seat.



Technical Data for Some Modern Executive Aircraft

Constructor and type	Country *	Engine type and power	Span (ft) Length (ft)	Wing area (sq. ft)	Empty wt. (lb) Gross wt. (lb)	Fuel capacity (Imp. gal)	Cruising speed knots at height (ft)	Range (n.m.) Service ceiling (ft)	Climbing speed f/m Takeoff distance (ft) **	Remarks
I. Piston-engined executive aircraft										
Four-seaters										
Aero 145	CS	M332 2×140 h.p.	40.1 25.5	183	2112 3520	72	132 4000	900 19000	980 1500	Further development of the Super Aero.
Hampshire BH.1 Halcyon	GB	Walter Minor 2×105 h.p.	31.3 23.4	153	1030 2000	54	128 5000	770 27000	1700 1000	Prototype in construction.
Simmering-Graz-Pauker M.222 Flamingo	ATR	Lycoming O-320-A 2×150 h.p.	36.0 28.9	183	2530 3850		145	690 21000	1400 1860	Series production (25 aircraft) expected to start in Autumn, 1961.
Basco Super V	USA	Lycoming O-360-A1A 2×170 h.p.	32.8 24.7	176	2010 3390	91	160	1100 23000	1550 1120	Single engine Beech Bonanza converted by Bay Aviation Services Co. (Basco) formerly Oakland Co. Cost of conversion according to re-equipment desired, max. $26,700.
Five-seaters										
L 200A Morava	CS	M337 2×210 h.p.	40.1 28.3	185	2800 4270	94	148	900 21500	1580	
Piaggio P.136L-2	ITL	Lycoming GSO-480 2×340 h.p.	44.4 35.5	269	4650 6580	158	165 12500	768 [1] 25000		Amphibian. [1] At 50% engine power. Flight altitude 14000 ft.
Beech B95A Travel Air	USA	Lycoming IO-360-B1A 2×180 h.p.	37.8 25.4	198	2550 4180	95	170 [1] 10000	860 [2] 18000	1250 1280	[1] At 75% engine power. [2] At 168 kts, plus reserves.
Beech 55 Baron	USA	Continental IO-470-L 2×260 h.p.	37.8 25.6	198	2960 4870	93	188 [1] 7000	1040 [2] 18000	1650 1250	[1] At 75% engine power. [2] Reserves for 45 minutes.
Cessna 310F	USA	Continental IO-470-D 2×260 h.p.	36.0 29.5	174	3040 4820	86	188 7500	1140 [1] 21000	1800 1390	[1] At 145 kts and 9500 ft altitude. 108 Imp. gals fuel; no reserves.
Cessna Skyknight	USA	Continental TISO-470-B 2×260 h.p.	36.0 29.5	174	3170 5000	86	210 18000	1220 [1] 28000	1860 1465	Delivery in August, 1961. [1] At 180 kts and 23000 ft altitude, 108 Imp. gals fuel; no reserves.
Piper PA-23-160 Apache G	USA	Lycoming O-320-B 2×160 h.p.	37.0 27.2	204	2320 3800	91	143 6500	1080 [1] 17000	1280 1190 [2]	[1] Economical cruise. [2] Takeoff distance.
Piper PA-23-250 Aztec	USA	Lycoming O-540 2×250 h.p.	37.0 27.7	205	2850 4780	122	175 6500	1200 [1] 22500	1660 1100	[1] At 45% engine power and 9500 ft altitude.
Six-seaters										
Dornier Do 28	WG	Lycoming O-540-A1A 2×250 h.p.	45.3 29.6	263	3600 5100	102	135 6560	635 [1] 20500	[2] 900 [3]	STOL: [1] At 130 kts. [2] Time to 10000 ft about 9 minutes. [3] At 4080 lb gross weight and no wind.
Rhein-Flugzeugbau RF 1	WG	Lycoming O-540-A1A 2×250 h.p.	46.3 42.9	350	3950 5940	76	138	790 [1] 20300	1140 500	STOL: [1] With extra fuel in wing-tip tanks (150 Imp. gals). Reserves for 30 minutes.
Aero Commander 720 Alti-Cruiser	USA	Lycoming GSO-480-B1A6 2×340 h.p.	49.5 35.1	255		186	195 10000	1350 [1] 25500	1625 1265	Pressurized cabin; [1] At economical cruising speed
Seven-seaters										
De Havilland Dove 8	GB	De Havilland Gipsy Queen 70 Mk.3 2×400 h.p.	57.0 39.2	335	5920 8930	169	158 8000	550 2700	1135 1740	
Aero Commander 500 B	USA	Lycoming IO-540 2×290 h.p.	49.5 35.1	255	4275 6750	130	185 10000	1080 [1] 20500	1450 1550	[1] At 55% engine power. Altitude 10000 ft. Reserves for 30 minutes.
Aero Commander 560 F	USA	Lycoming IGO-540 2×350 h.p.	49.5 35.1	255	4570 7000	185	125 10000	1270 [1] 21900	1750 1070	[1] At 55% engine power. Flight altitude 10000 ft. Reserves for 30 minutes.
Aero Commander 680 F	USA	Lycoming IGSO-540 2×380 h.p.	49.5 35.1	254	4720 7950	186	210 10000	1200 [1] 28500	1660 1380	[1] At 55% engine power. Altitude 15000 ft. Reserves for 30 minutes. Version 680 FP has pressurized cabin.
Beech J50 Twin-Bonanza	USA	Lycoming IGSO-480 2×340 h.p.	45.9 31.5	285	4450 7375	191	180 10000	1040 [1] 29150	1270 1450	[1] Reserves for 45 minutes.
Eight-seaters										
De Havilland Australia DHA-3 Drover Mk.4	AUS	Lycoming O-360-A1A 3×180 h.p.	57.0 36.5	325	4500 6500	130	115 5000	505 18000	1040 750	
Max Holste MH.350 Broussard Major	FRN	Continental GIO-470A 2×315 h.p.	49.8 35.0	301	4530 6950	120	150 3500	425 [1] 18050	1380 1110	[1] No wind, economical cruising speed 138 kts. Altitude 3500 ft. 30 minutes holding. Gross weight 6600 lb.
Piaggio P.166	ITL	Lycoming GSO-480-B1C6 2×340 h.p.	46.9 38.1	286	5180 8115	200	175 12470	760 [1] 25500	1240 2050	[1] At 55% engine power. Altitude 14500 ft. 1765 lb payload.

* CS = Czechoslovakia; GB = Great Britain; ATR = Austria; USA = United States of America; ITL = Italy; WG = West Germany; AUS = Australia; FRN = France; ISR = Israel; SWE = Sweden; SWI = Switzerland. ** Over 50 ft obstacle.

Constructor and type	Country *	Engine type and power	Span (ft) Length (ft)	Wing area (sq. ft)	Empty wt. (lb) Gross wt. (lb)	Fuel capacity (Imp. gal)	Cruising speed knots at height (ft)	Range (n.m.) Service ceiling (ft)	Climbing speed f/m Takeoff distance (ft) **	Remarks
Nine-seaters										
Beech 65 Queen Air	USA	Lycoming IGSO-480 2×340 h.p.	45.9 33.3	277	4660 7700	192	170 10000	910 [1] 31300	1300 1560	[1] Reserves for 45 minutes.
Aircraft with ten seats and above										
De Havilland Heron 2	GB	Gipsy Queen 30 Mk.2 4×250 h.p.	71.5 48.5	499	8480 13500	416	155 8000	1280 17200	1075 2425 [1]	Ten seats. [1] According to Airline method.
Scottish Aviation Twin Pioneer 3	GB	Alvis Leonides 531/8B 2×600 h.p.	76.5 45.2	670	10240 14600	250	110 5000	570 18000	920 1100	Twelve seats: STOL.
Beech Super G18S	USA	P&W Wasp R-985-AN14 2×450 h.p.	49.6 35.1	361	5910 9700	265	175 5000	1020 21600	1410 1980	Eleven seats.
Lockheed Air Service Super 26	USA	P&W R-2800 2×2400 h.p.	70.0 50.8	596	24890 35000	1140	320	2130	3500 [1]	Eleven seats. Converted Douglas B-26. [1] Runway distance.
Pacaero Learstar Mark I	USA	Wright Cyclone R-1820 2×1425 h.p.	66.1 51.0	551	15000 24000	935	240 10000	3250 22950	1490	Fourteen seats. Based on Lockheed *Lodestar*.

II. Turboprop executive aircraft

Latécoère 870	FRN	Turboméca Astazou II 2×530 s.h.p.	39.3 38.7	162	 7515		310 16400	 39350		Eight seats.
SIPA 272 Présence	FRN	Turboméca Astazou II 2×530 s.h.p.	57.0 45.6	355	6615 10735		220 19685	1320 33950	1640 1755	Twelve seats.
Sud-Aviation Dassault Communauté A1	FRN	Turboméca Bastan IV 2×1000 e.s.h.p.	59.8 54.4		9260 16940		255 20000	1540 [1]	 3080 [2]	Ten seats. [1] 1545 lb payload, cruising speed 210 kts, 5% fuel reserves. 15 kt headwind. 30 minutes holding. [2] Runway distance at 16755 lb gross weight. Sea level standard atmosphere.
Grumman Gulfstream	USA	Rolls-Royce Dart RDa. 7/2 2×2105 e.s.h.p.	78.2 63.6	610	21900 33600	1290	305 25000	2000 [1] 35000	1900 4025 [2]	Twelve seats. [1] With max. fuel, 170 n.m. diversion and 45 minutes holding. [2] Over 35 ft obstacle.

III. Turboprop conversions from piston-engined aircraft

SFERMA/Beech PD.18S	FRN USA	Turboméca Bastan 2×440 s.h.p.	49.6		 11000		225		1970 920 [1]	Eleven seats. [1] Takeoff distance.
SFERMA/Beech PD.146 Turbo-Travel Air	FRN USA	Turboméca Astazou I 2×470 s.h.p.	37.8 25.3	194	 5095		255		2855 490	Four seats.
SFERMA/Beech Marquis	FRN USA	Turboméca Astazou IIA 2×440 s.h.p.	37.8 25.3		3090 5400	170	225 9840	740 29500	3150 985	Five seats; developed from the *Baron*.

IV. Executive aircraft with turbojet engines

Morane-Saulnier MS.760 Paris II	FRN	Turboméca Marboré VI 2×1060 lb	33.2 33.0	194	5510 8600	205 [1]	340 19685	1100 [2] 32800		Four seats. [1] Plus 198 Imp. gal in leading edge and wing-tip tanks. [2] At 25,900 ft at 265 kts.
Potez/Heinkel CM.191	FRN WG	Turboméca Marboré VI 2×1060 lb	39.4 32.8		4520 8475	[1]	370 [2]	860 [3] 35760 [4]	2890 2740 [5]	Four seats. [1] 2500 lb. [2] Max. speed. [3] At 29530 ft. [4] At 200 f.p.m. climb. [5] Takeoff distance.
De Havilland DH.125 Jet Dragon	GB	Bristol Siddeley Viper 20 2×3000 lb	44.0 43.6	342	 18000		385	1270		Eight seats.
Israel Aircraft (Bedek) B.101C	ISR	General Electric CJ-610-2B 2×2400 lb	40.3 35.7	239	6505 12500		415 32800	1430	5900 2625 [1]	Eight seats. [1] Takeoff distance.
Procaer F.400 Cobra	ITL	Turboméca Marboré IIF 1×880 lb	28.5 26.5	132	2425 3750	113	255 13100	29530 [1]	 2300 [2]	Two seats. [1] Flight endurance 1 hour 50 minutes. [2] Takeoff distance.
Saab 105	SWE	Turboméca By-pass 2×1540 lb	31.1 34.4	175	4440 7895	310	387 26250	1430 [1] 43200 [2]	4720 2130	Five seats. [1] At 400 m.p.h. at 36,000 ft. [2] 100 f/m. climb at 6620 lb gross weight.
Aero Commander 1121 Jet Commander	USA	General Electric CJ-610 2×2850 lb	43.3 48.0	303	6800 14000	770	360 20000	1480 [1] 40000	7000 1900	Six seats; first flight likely in April 1962; pressurized cabin. [1] Cruise height 35,000 ft.
Cessna 407	USA	Continental 356-9 2×1400 lb	37.9 31.6	200	4660 9300	[1]	396 35000	1360 46400	3680 2850	Four seats; developed from the T-37; pressurized cabin. [1] Fuel capacity 3,640 lb.
Lockheed JetStar	USA	P&W JT12A-6 4×3000 lb	53.7 66.5	542	18450 38640	2190	460 20000	2450 [1]	3300	Ten seats; pressurized cabin. [1] With eight passengers, plus reserves for 45 minutes.
McDonnell 220	USA	Westinghouse J34 4×3000 lb	57.6 66.5	550	40930		445 44900	2000	 4135 [1]	Twelve seats. [1] Takeoff distance.
North American Sabreliner	USA	P&W JT12-6 2×3000 lb	44.5 43.2	342	9960 17760	890	425 40000+	1620 20000 [1]	2500 [2]	Six seats. [1] With one engine. [2] Takeoff distance at SL. For description see *Interavia* 5/1961, page 702.
Douglas/Piaggio PD-808	USA ITL	P&W JT12 2×3000 lb					425 40000			Six seats.
SAAC 23 Execujet	USA SWI	General Electric CJ-610-2B 2×2400 lb	34.6 37.3	215	5150 11200	[1]	425+ 30000	1800 [2] 40000+	6000 4200 [3]	Eight seats. [1] 4600 lb. [2] At 40,000 ft with max. fuel capacity and reserves for 45 minutes. [3] CAR take-off distance.

* CS = Czechoslovakia; GB = Great Britain; ATR = Austria; USA = United States of America; ITL = Italy; WG = West Germany; AUS = Australia; FRN = France; ISR = Israel; SWE = Sweden; SWI = Switzerland. ** Over 50 ft obstacle.

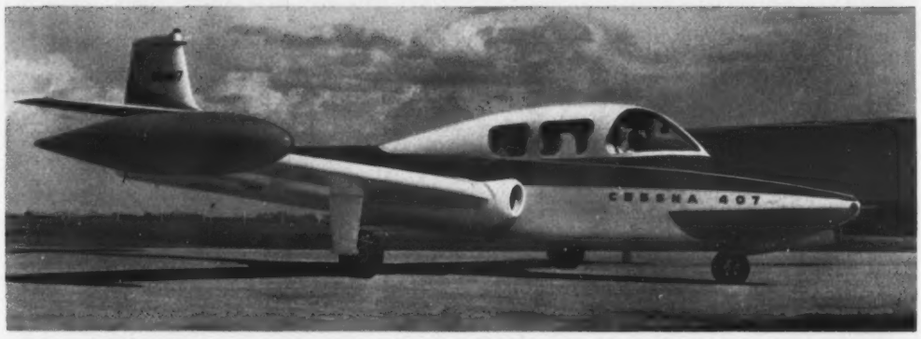
sands of smaller businesses able to afford executive aircraft and in a position to put them to profitable use.

• For economic and political reasons, American industry is decentralizing at a faster and faster pace. For concerns which are obliged to operate branches in widely separated towns, executive aircraft are indispensable. For example, Mrs. Walter H. Beech, President of the Beech Aircraft Corporation, calculates that, even if a business man uses one single small 150 m.p.h. executive aircraft for only 300 hours per year, he covers over 45,000 miles in a comfortable and rational manner. To achieve the same mileage by car, would involve not 300 hours flying, but 1,125 hours driving on overloaded highways. And 300 hours per year is not by any means the upper utilization limit for an executive aircraft; many of them, in fact, do as much as 500 or 600 hours, and even more.

• In many of the newly developing countries the executive aircraft is practically the only possible means of transport.

We do not wish to extend this list of arguments, the more so as we are ready to admit that, in many ways, the executive aircraft constructors have so far been right in their optimistic appreciation of the situation. As far as the USA is concerned, the industry's prospects are favoured by fuel prices which are much cheaper than in Europe. On the other hand, in the European business man's calculation, the pay of pilots and mechanics is not such a big item. It is revealing that the estimates of operating costs published by American aircraft constructors usually pass over in silence the question of wages and salaries.

All in all, even without forecasting in terms of figures, one can reasonably state that executive aircraft production has proven itself viable. The producers can look forward to the future with confidence, provided too many competitors do not come into the market with too many new developments, provided the military authorities are willing to skim off possible excesses in supply, and provided the air traffic control authorities—particularly in Europe—allocate the executive aircraft a better place in airspace. ←←



The 407 tourist aircraft by Cessna is a four-seat development of the well-known Cessna T-37 jet trainer and is equipped with the Continental 356-9 engines (civil version of the J69 military engine). The four-seat aircraft is, of course, equipped with a pressurized cabin, and it can cover distances up to 1,500 miles at an altitude of some 35,000 ft.

Operating costs for the Beechcraft 65 Queen Air

This specimen calculation of operating costs for a piston-engined executive aircraft is taken from a Beech Aircraft Corporation publication, and currency is the US Dollar.

		Cost Per Hour			
		360 hrs. 72,000 miles/year	480 hrs. 96,000 miles/year	600 hrs. 120,000 miles/year	1,080 hrs. 216,000 miles/year
Direct Operating Costs					
1	Fuel	$ 12.58	$ 12.58	$ 12.58	$ 12.58
2	Oil	$ .59	$ .59	$ .59	$ .59
Indirect Operating Costs					
3	Depreciation	$ 53.33	$ 40.00	$ 32.00	$ 17.78
4	Hangar rental	$ 2.95	$ 2.33	$ 1.95	$ 1.28
5	Inspections, repairs and parts	$ 15.19	$ 15.19	$ 15.19	$ 15.19
6	Insurance				
	hull insurance	$ 6.67	$ 5.00	$ 4.00	$ 2.22
	public liability	$ .07	$ .05	$ .04	$ .02
	passenger liability (6 seats)	$ .47	$ .35	$ .28	$ .16
	property damage	$ .08	$ .06	$ .05	$ .03
7	TOTAL direct+indirect operating costs	$ 91.93	$ 76.15	$ 66.68	$ 49.85
8	Cost per mile flown, before tax savings	46.0c	38.1c	33.3c	24.9c
9	Cost per mile flown after tax savings	22.1c	18.3c	16.0c	12.0c
10	Cost per seat mile, before tax savings (6 seats)	7.7c	6.4c	5.6c	4.2c
11	Cost per seat mile, after tax savings (6 seats)	3.7c	3.1c	2.7c	2.0c

Basis of Computation

1 *Fuel.* Fuel consumption is based on recommended cruise power of 65% at 10,000 ft, with allowance for normal radio engine warm-up, taxiing, and climb to altitude. Computed at 34 U.S. gallons per hour at $.37 per gallon.

2 *Oil:* Oil consumption includes allowance for oil change every 100 hours. Computed at 1 quart burned per hour plus 8 U.S. gallons changed each 100 hours at a cost of $1.80 per U.S. gallon.

3 *Depreciation Allowance:* Depreciation of the hull is spread over a 5-year period (16% per year) with a 20% residual value. Based on list price of $120,000 for standard aircraft.

4 *Hangar Rental:* Hangar rental is based on a cost of $900 per year plus $.45 per hour storage away from base.

5 *Inspection, Repairs, and Spares:* Includes reserve towards 900-hour engine overhaul.

6 *Insurance:* Equipment (hull) insurance includes all risk, fire, theft, crash, etc. on the ground and in flight. Cost per hour is based on maximum coverage. Public liability is based on $100,000 to $300,000 coverage. Passenger liability is $100,000 per person. Property damage is based on $100,000 coverage. Rates are based on 3-year insurance policies, as obtainable under Beech Finance Plans.

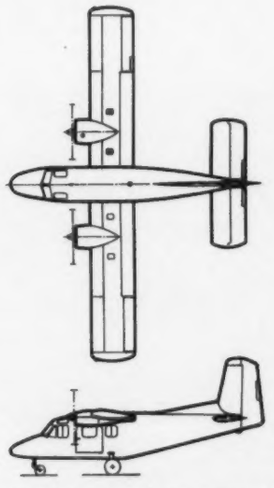
7 *Total Direct and Indirect Operating Costs:* These are based on a cruising speed of 200 m.p.h.

8 *Cost Per Mile Flown Before Tax Savings:* Hourly utilizations and annual mileages are based on a cruising speed of 200 m.p.h.

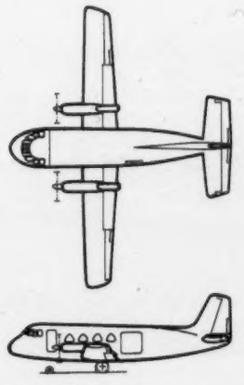
9 *Cost Per Mile Flown Tax Savings:* Assumes user company is subject to 52% tax rate.

10 *Cost Per Seat Mile Before Tax Savings (6 seats):* Hourly utilizations and annual mileages are based on user cruising speed of 200 m.p.h.

11 *Cost Per Seat Mile After Tax Savings (6 seats):* Assumes user company is subject to 52% tax rate.



The Nord/Max Holste MH.350 *Broussard Major.*



The SIPA.272 *Présence.*

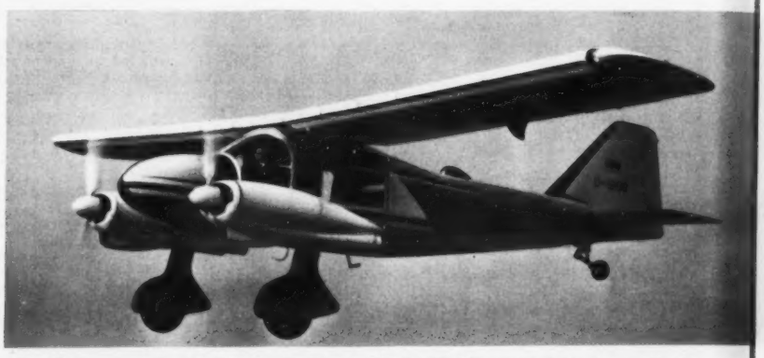
Little is so far known about the Piaggio/Douglas PD-808 project for a touring and training jet aircraft. In its dimensions and weights, this low straight-winged monoplane is roughly comparable to the de Havilland 125 or the Aero Commander 1121. The engines are expected to be two Pratt & Whitney JT-12 turbojets.

A Mixed Bag of

The preceding article gave a compressed review of the present state of executive aircraft and of future development trends. Since it was not possible to include every type, we are using these two pages to illustrate some further executive and tourist aircraft produced by the aircraft industries in both the USA and Europe. The prospects for the various categories are difficult to assess. It is,

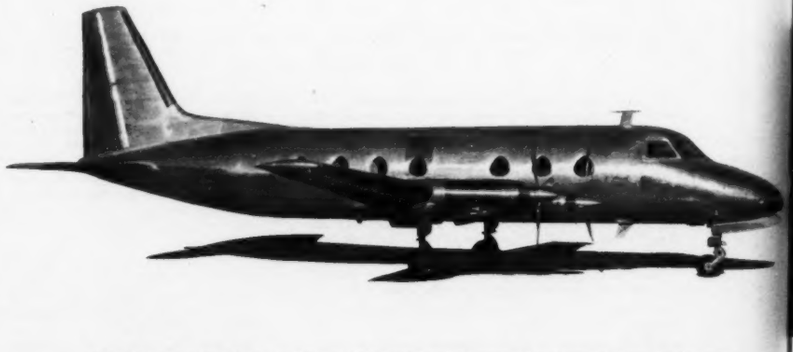
In the four-seat Wassmer *Super IV* touring aircraft over Venice. This relatively expensive model is fittted with a 188 h.p. Lycoming O-360-A1A engine and has a maximum speed of 171 m.p.h. Empty weight and takeoff weight are 1,500 lb and 2,645 lb respectively.

The Czechoslovakian L200 *Morava,* built by Ladislav Smrcek, flew for the first time in April, 1957. To start with, it was powered by two 160 h.p. engines, but now it is equipped with two M337 supercharged engines of 210 h.p. each. The Soviet State Airline, Aeroflot, has purchased 75 of these aircraft. A turboprop version (designated L300) is understood to be under development.



By using numerous parts of its Do 27, Dornier-Werke GmbH produced the six-seat Do 28 (two Lycoming O-540-A1A engines each of 250 h.p.), which flew for the first time on April 29th, 1959. Thanks to a minimum speed of about 44 m.p.h., this aircraft is suitable for use on very small landing fields.

The first BEAGLE type, the A.109 *Airedale,* is powered by a 180 h.p. Lycoming engine and its maximum speed is about 150 m.p.h. Span is 36 ft, length 25.8 ft, and height 9.1 ft. For further data, see *Interavia* 5/1961, page 554. The *Airedale's* comfortably laid out cabin has room for four.



Potez-Fouga also offers its Potez 840 short-haul commercial aircraft (four Turboméca *Astazou II* engines, each 530 s.h.p.) in an executive version. The first flight of this model took place on April 29th, 1961, and the series version is expected to be available as from April, 1963. Span 63 ft: takeoff weight 17,200 lb; cruising speed of 325 m.p.h. at 20,000 ft.

◀

Fokker or, as the case may be, Fairchild supplies *Friendships* laid out as luxury executive aircraft. The F.27 shown here belongs to Helmut Horten, Managing Director of a large West German department store. The aircraft has been equipped with numerous radio and navigation equipment and, at takeoff weight of 35,000 lb and altitude of 20,000 ft, reaches a cruishing speed of 306 m.p.h. It is powered by two Rolls-Royce *Dart RDa.7Mk 528* engines, each of 1,910 s.h.p. With maximum fuel supply and 5,000 lb payload, the aircraft has a range of 1,505 miles (with reserves).

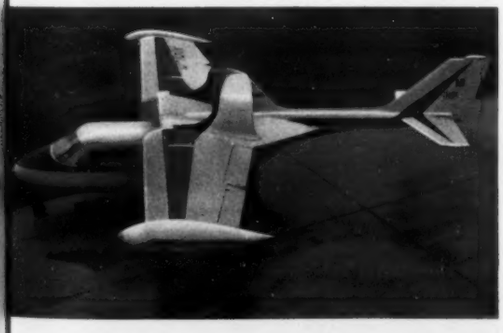
Executive Aircraft

however, to be assumed that even luxurious and expensive aircraft, such as the four-engined Potez 840, can be profitably employed by large concerns, provided that top management understands how to make proper use of them. We show the Fokker *Friendship* as representative of all the models originally designed as commercial aircraft and now offered as luxury models for executive use.

The P.166 land version, developed from the Piaggio P.136 amphibian aircraft. It has eight seats and has found customers throughout the world for business, feeder, and aerial photography purposes. The Italian Air Force has ordered 21 aircraft of this type for use as couriers.

Although its weight is only 1760 lb, the Morane-Saulnier MS.885 *Super Rallye* offers adequate comfort to three business travellers (our picture shows the MS-880 version, which can be fitted with either a 90 h.p. or a 100 h.p. engine). With the Continental O-320A engine of 145 h.p., the aircraft's maximum speed is 143 m.p.h. Span is 31.36 ft, empty weight 1080 lb, and takeoff weight 1,810 lb.

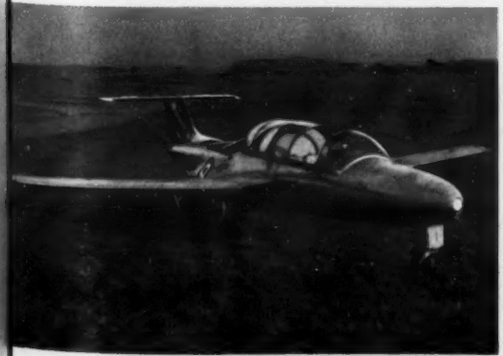
The well-known reliability of the Kl 107 Klemm is again a feature of the Bölkow F207, but the latter has considerably increased cabin comfort, a a fourth seat, and more extensive equipment. The F207 is built mainly in wood and plastics, and this touring aircraft, equipped with a 188 h.p. Lycoming engine, has a maximum speed of 158 m.p.h. Its lean-mixture power range is quoted as 808 miles, fuel consumption being 6.9 I.G. per hour. Span is 35.47 ft, empty weight 1,543 lb, and maximum takeoff weight 2,645 lb.

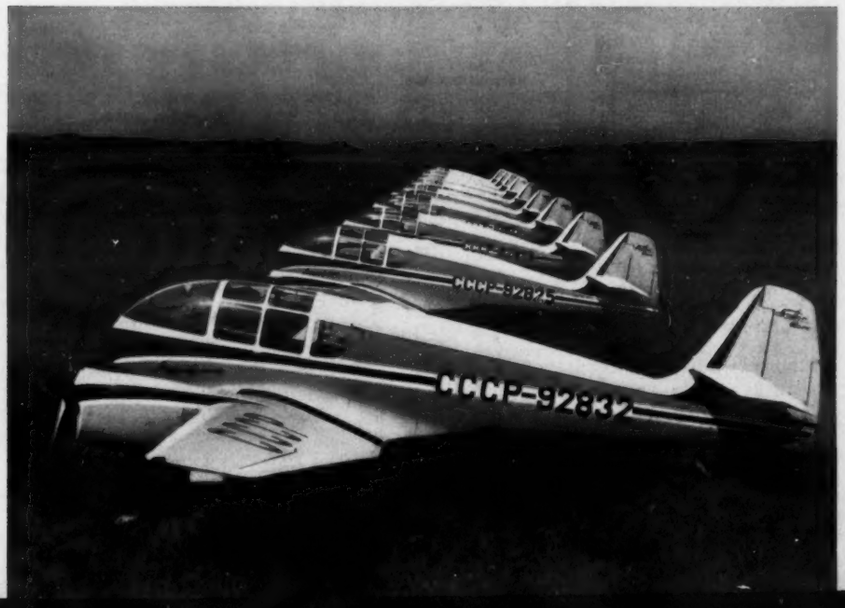


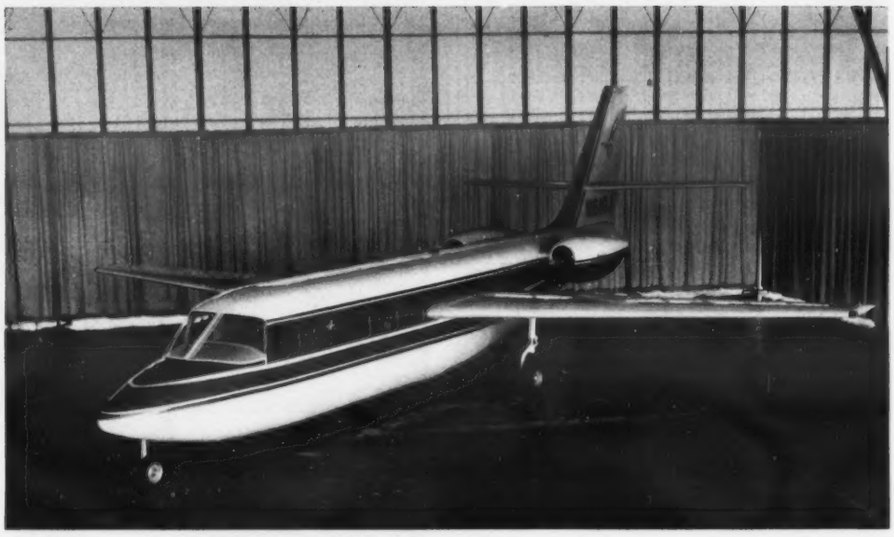
By using a ducted propeller, Rhein-Flugzeugbau GmbH is trying to improve the performance of its RF-1, especially in respect of takeoff. The forward part of the spacious cabin accomodates the pilot and one passenger side by side. Behind, separated by a table, are bench-type seats for four more passengers. Construction is in metal, with extensive use of plastic.

These ten *Super Aeros*, fitted with Walter *Minor* 4-*III* engines of 105 h.p., are in use by Aeroflot as air taxis. The Czechoslovakian aviation industry is currently producing the Aero 145, a further development of the *Super Aero* and equipped with stronger engines.

Morane-Saulnier has derived a five-seat pressurized cabin version, designated *Paris III*, from the MS.760 *Paris II* pictured here. Anyone still possessing a *Paris* fitted with a Turboméca *Marboré II* (880 lb thrust) can have it converted to the *Marboré VI* (1,060 lb thrust).







Full-scale mock-up of the *Jet Commander*. As in the case of the earlier *Aero Commanders*, no stairs are required for access.

Aero Commander–Comfort at Jet Speed

The 1121 Jet Commander

When the Aero Design and Engineering Company brought out their *Aero Commander* 520 barely ten years ago, this model encountered sharp competition in the executive aircraft market. It nevertheless succeded, against all expectations, in establishing itself successfully, and is counted today among the best-sellers. There are at present about a thousand *Aero Commanders* (various versions) in use around the world. Encouraged by this success, the manufacturer—known since October 1960, as Aero Commander Inc.—is now offering a jet-powered further development of the proven basic design.

This project undoubtedly received strong support from Aero Commander Inc.'s new parent company, the Rockwell-Standard Corporation, a well-established firm in the field of automotive equipment, which brought the necessary understanding of business plane manufacturing requirements, and was in a position to promote every aspect of Aero Commander's project, including finance.

Nevertheless, the decision to produce the 1121 *Jet Commander* came only after several years of preparatory study, during which a number of basic requirements were established for jet aircraft for business use. Colonel W.F.Rockwell, Chairman of the Aero Commander Corporation, has formulated these essentials as follows:

- It must have adequate size for comfort.
- It must be capable of speeds up to 500 m.p.h. and still provide adequate range.
- Stability must equal that of the piston-engined *Aero Commander*.
- It must operate safely and easily from short airstrips.
- It must be available at a competitive price.

Aero Commander has no doubt that, in the *Jet Commander*, it has a design which fulfils all these conditions.

Brief description

The Aero Commander 1121 *Jet Commander* is an all-metal aircraft of conventional construction with a straight trapezoidal wing and lightly swept-back tail assembly (see two-view drawing on page 1081). It is powered by two General Electric CJ-610 turbojets, mounted aft, each developing 2,850 lb takeoff thrust at sea level and standard atmosphere.

The two-panel *wing structure* comprises two main spars, and a sub-spar on which the main landing gear loads are carried. The wing skins are machined from aluminum alloy plates and attached to the spars by rivets and screws. The entire interior of the wing structure is sealed, thus providing an integral fuel tank. The wing tips are of plastic. Split flaps extend over approximately 53 percent of each wing panel semi-span. The ailerons have electrically-actuated trim tabs; they are fully mass-balanced and partly aero-dynamically balanced.

The structure of the *tail assembly* resembles that of the wings. The elevators and rudder are similar to the ailerons in materials and construction, and are equipped with electrically-operated trim tabs. The upper 12 inches of the vertical fin is of plastic construction, to enclose the antennas.

The *fuselage* is constructed of ring-shaped frames (some of which are integrally machined), covered with a longitudinally-stiffened smooth contour skin. The passenger cabin has seven windows, 14×15 ins in size; four on the right-hand side and three on the left-hand side. The pilot's cockpit enclosure is provided with two

Design Technical Data for the Jet Commander

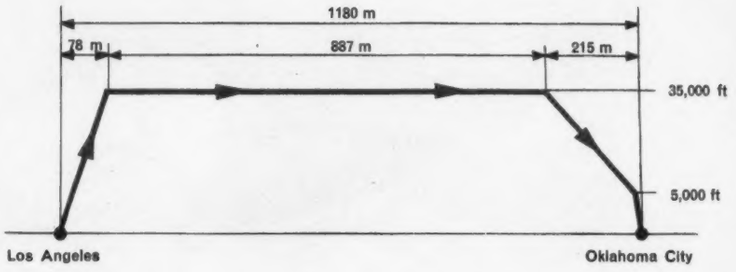
Engines: 2 General Electric CJ-610 jet engines, each with a takeoff thrust of 2,850 lb

Wing span	43.31 ft	Sweep angle at quarter-chord	4.63°
Length over-all	48.00 ft	Horizontal tail area (total)	65.25 sq.ft
Height over-all	14.75 ft	Vertical tail area (total)	44.70 sq.ft
Maximum cabin height	59.50 in	Empty weight (equipped)	6,800 lb
Maximum cabin width	56.50 in	Maximum takeoff weight	14,000 lb
Passenger compartment length	101.75 in	Cruising speed at over 20,000 ft	Mach 0.8
Total wing area	303.3 sq.ft	Stall speed (clean)	111 m.p.h.
Aspect ratio	6.19	Sea-level rate of climb	7,000 f.p.m.

large windshield panels and two side windows. The cabin entry door and the door to the 31 cu.ft. baggage compartment are located on the left side of the fuselage.

The hydraulically-operated *landing gear* consists of dual-wheeled nose gear (16 in × 4.4 in tyres), which retracts aft into the fuselage, and two main wheels (24 in × 7.7 in) which retract outward into the wings. The main landing gear can be lowered independently of the nose gear and used as an air brake.

The *control system* of the 1121 is mechanical, and dual control-columns and rudder pedals are provided. The controls are linked to the surfaces by means of push-pull rods and pulley-and-cable systems.



Typical flight profile for the *Jet Commander* (for explanations see text).

Systems

In its integral wing fuel tanks, the *Jet Commander* can carry 725 US gallons, and a fuselage tank located in the central area above the wings provides another 200 gallons of fuel-carrying capacity.

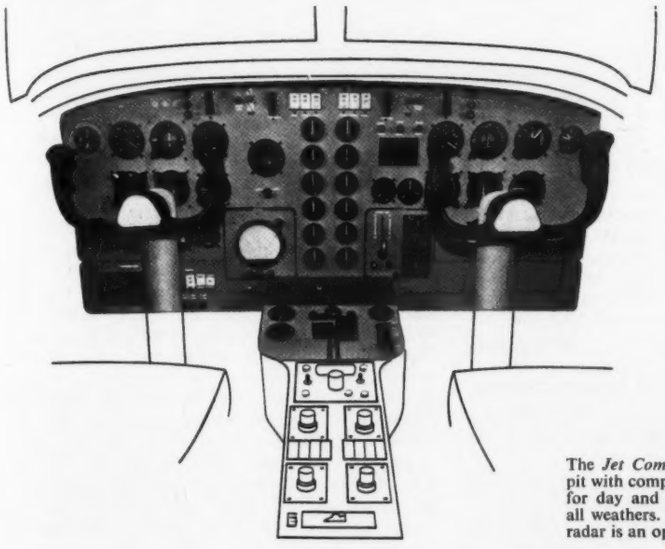
The *electrical* system is primarily a 28-volt d.c. system, supplemented by 115-volt 400-cycle a.c. power to supply such equipment as the "X"-band radar and the autopilot. The engines are started electrically.

The *hydraulic* system includes two pumps, with a service pressure range of 1,500 to 3,000 p.s.i. In addition to the landing gear, the landing flaps, wheel brakes, and nose-wheel steering are hydraulically powered.

The air-conditioning and pressurization system maintains a cabin pressure corresponding to about 8,000 ft for all aircraft altitudes up to 35,250 ft. The turbo-compressors are driven by bleed air from the engines. The *Aero Commander's* air-conditioning system also provides cooling on the ground and cabin temperature may be regulated to ± 3 °F. In case of pressurization system failure, two separate breathing systems are available, capable of supplying oxygen to the pilot, co-pilot, and four passengers for 30 minutes at 35,000 ft flight altitude.

The optional *navigation and communications* equipment includes two VHF receivers, a marker beacon receiver, two glide slope receivers, two VHF transmitter/receivers, an "X"-band radar and a Sperry SP-3 autopilot.

The *all-weather* systems of the *Jet Commander* include electric de-icing of the windscreen, and de-icing of the engine inlet effected by bleed air from the engine. Wing and tail assembly leading-edges can also be provided with electric de-icers as optional equipment.



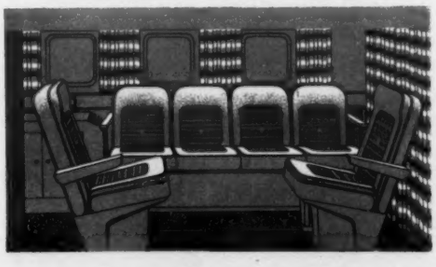
The *Jet Commander's* cockpit with complete equipment for day and night flying in all weathers. Meteorological radar is an optional extra.

Interior furnishings

The normal passenger seating capacity of the *Jet Commander* is four persons, but seating accomodation for six passengers can be provided as optional equipment. Between the cockpit and the passenger cabin, there is a lavatory and vestibule compartment equipped with a small galley. In addition to cabin flood lighting, there is an individual reading lamp for each seat.

Among other items of standard cockpit equipment are a Mach airspeed indicator and an accelerometer, as well as the usual turbojet engine monitoring instruments.

One of the numerous possible layouts of the passenger cabin. With four seats, a table can be installed.



Performance

One of Aero Commander's most telling sales arguments is the assurance that the new model can utilize the same airstrips as its piston-engined predecessor. At sea-level, and at 59 °F standard temperature, the *Jet Commander* takes off at 132 m.p.h. after a run of 1,932 ft, and clears a 50-ft obstacle 2,129 ft from the starting point. On an airstrip at an altitude of 5,000 ft, and at a temperature of 82 °F, it requires 3,390 ft to take off at 148 m.p.h., and 3,703 ft to clear a 50-ft obstacle. Both of these cases are based on a maximum gross weight of 14,000 lb.

Maximum range is 1,930 miles, based on the following assumptions: gross weight 14,000 lb; four passengers, each with 40 lb of baggage; 6,260 lb of fuel; zero wind; takeoff at sea-level, standard atmosphere; two minutes for takeoff, 13 minutes for climb to 35,000 ft cruising altitude, 400 m.p.h. cruising speed with 85 percent engine output, four minutes for descent to 20,000 ft with a 30-minute hold at that altitude, four minutes for descent to 5,000 ft with a five-minute hold, ten minutes for approach flight and landing; 150 lb of fuel remaining upon landing.

To illustrate the performance and fuel requirements of the *Jet Commander* with a practical example, a typical flight from Los Angeles to Oklahoma City, (1,180 miles) can be taken (see sketch). At takeoff with a gross weight of 14,000 lb, a climb at maximum continuous rating to the 35,000 ft cruising altitude will require 0.23 hours and consume 748 lb of fuel. Cruising at 500 m.p.h. with 90 percent of maximum power will take 1.76 hours and burn 2,690 lb of fuel. Descent at 288 m.p.h. to 5,000 ft then requires 0.57 hrs and 813 lb of fuel, followed by a 5-minute hold at 5,000 ft at 230 m.p.h. involving 0.083 hrs and 140 lbs of fuel. The final ten minutes necessary for approach flight landing at flight idle RPM account for 0.166 hours and 157 lb of fuel. The total flight time is thus 2.81 hours and total fuel consumption 4,548 lbs.

The decision of Aero Commander Inc. to go straight from the piston-engine to jet propulsion can hardly have been taken without thorough market research, and one may reasonably expect the *Jet Commander* to have as successful a career as its piston-engined predecessors. The first flight of this new jet executive aircraft is set for April, 1962, and deliveries of the series model should start in Summer or Autumn, 1963. ←

Executive Aircraft

Saab's Small Jet for Airman and Business Man

The Swedish aircraft industry's entry into the touring and liaison aircraft market has long been awaited. Therefore, the first public presentation by Svenska Aeroplan Aktiebolaget of a model of its Saab 105 at the Paris Show was not entirely unexpected. The first flight of the prototype is scheduled for mid-1962, and volume production should begin towards the end of 1962.

The basic criteria considered by the manufacturer for this four or five-seat model were both the civilian need for a business plane and the oft-repeated wish of the Swedish military services for a fast, light, multi-purpose aircraft suited to the geographical conditions of the country, with its long borders and narrow configuration. These requirements, and others, led to the development of the Saab 105, which, equipped with twin ducted-fan jet engines, will be offered for about 1,000,000 Swedish Crowns ($210,000) and, according to Saab, is suitable for a number of purposes, which are enumerated below.

Military Trainer: Although primarily intended for medium and advanced air force pilot training, the Saab 105 can also be used for primary training. The relative advantages or disadvantages of a side-by-side seating layout for pilots are debatable. Saab maintains that this seating arrangement provides the instructor with better control over the pupil than does the tandem system. Especially is this true of gunnery exercises—the Saab 105 may be quickly and easily armed—since the pupil's movements and reactions can be better monitored.

Airline Pilot Trainer: Side-by-side seating offers uncontested advantages for airline pilot training. Moreover, the rear seats can be occupied by two or three other trainee pilots undergoing primary instruction, performing navigation exercises, and so forth. With four men aboard, it is possible to change seats in flight, so that three students can successively pilot the aircraft. Since the range is over 1,550 miles, ample flying time is available to each pupil.

Liaison aircraft: The Saab 105 meets a long-felt need of the Swedish armed forces for a fast four-to-five seat liaison aircraft of domestic manufacture. Needless to say, the comfort provided by the civilian version is equally welcome in the military model.

Executive aircraft: A normal cruising speed of 400 m.p.h. at an altitude of 26,000 feet, relatively low operating costs due to the economical ducted-fan engines, the "built-in" safety of twin engines —a business concern can scarcely ask more of its private aircraft.

Air-mapping: When equipped with mapping cameras, the Saab 105 can be used for photo-mapping up to its service ceiling of about 40,000 ft. In addition, three persons can be carried aboard, and flight endurance without extra fuel is six hours.

Reconnaissance: In addition to a camera in the fuselage, other reconnaissance cameras can be mounted in pods under the wings. With its sea-level range of 700 miles, and its range of over 1,550 miles at an altitude of 26,000 feet, the reconnaissance version provides coverage over a wide area.

Air Ambulance: The two right-hand seats can easily be replaced by a stretcher, while the left rear seat can be occupied by an attendant. The loading and off-loading of a stretcher-borne casualty, however, presupposes a fair degree of dexterity.

Light Attack Aircraft: As shown in our illustration, the Saab 105 carries a very respectable arsenal of weapons. With 1,550 lb of armament and sufficient fuel for a sea-level radius of action of 100 miles combined with attack and reserve supply, the takeoff and landing runs are about 2,000 ft. The maximum radius of action under the same conditions is over 250 miles but, owing to the heavier fuel load, the required takeoff run increases to about 3,350 ft.

*

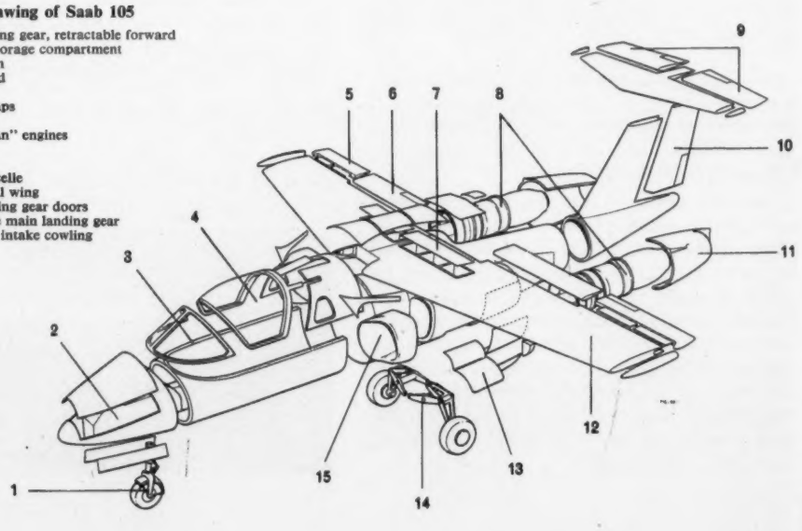
The Saab 105 is an aerodynamically clean, high-wing, all-metal aircraft with pleasing lines. The landing gear is retractable into the fuselage which, in addition to a roomy pressurized cabin, provides a compartment for equipment forward and luggage space aft. The main part of the fuel supply is stored in two integral fuselage tanks located behind the cabin. To satisfy present-day safety requirements, Saab engineers based their design on two engines; also, by placing the cabin well forward of the wings and by providing a generous expanse of windscreen and hood all around, excellent visibility is afforded, thereby promoting flight safety. The generously-dimensioned control surfaces, and the central location of the jet engines, should ensure stable, pitch-free flight conditions. The stream of hot exhaust gases makes it impossible to place the tailplane in a conventional position, and this led to the adoption of a T-shaped tail assembly.

The wing has two continuous spars, and is characterized by a slight negative dihedral and lightly swept-back aspect; the wing is rivetted in the middle and mounted as a complete unit on the fuselage. All control surfaces are statically and aerodynamically balanced; the rudder has an electrically operated trim tab, while the elevator and ailerons have geared trim tabs. The landing flaps, air brakes, and landing gear are hydraulically operated. In case of hydraulic system failure, the landing gear is manually released from the locked position, and lowers itself by its own weight and aerodynamic forces. Large wheels with single disc brakes ensure safe landings and, if desired, an anti-skid warning system can be added. According to the manufacturer, the Saab 105 can take off or land on hard grass runways as well as concrete runways, but it would seem that the narrow wheel track might constitute a handicap, especially in civil applications.

The constructor has attached great importance to the configuration of the pressurized cabin. In

Exploded drawing of Saab 105

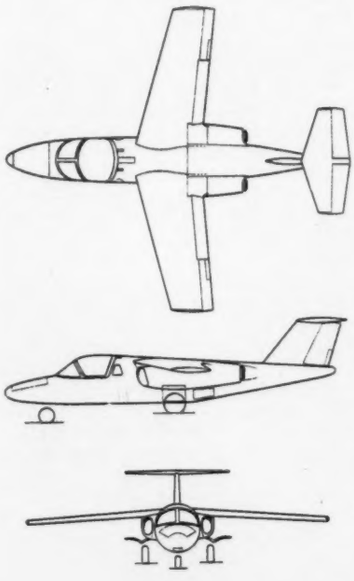
1 – nose landing gear, retractable forward
2 – forward storage compartment
3 – windscreen
4 – cabin hood
5 – ailerons
6 – landing flaps
7 – fuel tanks
8 – "ducted-fan" engines
9 – elevator
10 – rudder
11 – engine nacelle
12 – trapezoidal wing
13 – main landing gear doors
14 – retractable main landing gear
15 – engine air intake cowling



all speed ranges, the single-curved windscreen is bird-proof and the double-curved acrylic glass hood, when ejection seats are fitted, allows emergency ejection of the seat directly through the closed hood. Also, seat height can be adjusted in flight, and five different seating arrangements are available (see box). The instruments can be read from both front seats, and the centrally-located radio equipment used from either side. Space has been reserved for two VHF units and two ADF units, and there is provision for later installation of ILS and VOR equipment. The pressurized cabin is air-conditioned and temperature automatically regulated. At altitudes above 26,000 ft, the pressure maintained in the hermetically-sealed cabin is some 5 p.s.i. above the exterior atmospheric pressure. Windscreen fogging due to moisture condensation is prevented by a warm air blower. Connections for pressure suits and oxygen masks are standard equipment at both front seats, and can also be provided at the rear seats. The oxygen is carried in two 5-litre flasks (pressure 2,080 p.s.i.).

The two Turboméca *Aubisque* ducted-fan jet engines on either side of the fuselage can be seen in our three-view drawing, but the only data made public by the manufacturer concerns the static thrust, which is 1,540 lb. An estimate, to be treated with reserve, indicates that specific fuel consumption may be of the order of 0.6 lb/lb/h.

View of the Saab 105 cabin showing the main flight and navigation instruments, the dual flight controls, and engine control levers. Two ejection seats replace the fixed front seats.



The hydraulic system consists of two pumps, one on each engine, each with a service pressure of 3,000 p.s.i. One operates the wing flaps, the air brakes, and the landing gear, while the other provides pressure for the brakes. Fuel flow is handled by other pumps, and the construction of the fuselage tanks makes cross-feeding possible. The total capacity of the fuel tanks in the fuselage is 204 I.G., while that of the wing tanks is 106 I.G. Refuelling can be accomplished either by pressure or overwing methods.

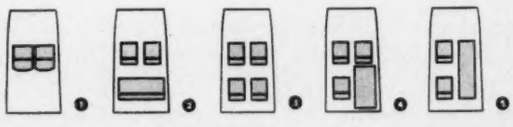
The elegance of the Saab 105 does not belie its suitability for military purposes. Five different types of weapon are easily mounted, and space is provided on the armament panel for the necessary selectors and controls, as well as for a gyro gunsight. Closer examination of the military aspects is outside the theme of this issue of *Interavia*, where the Saab 105 finds its place because, even without considering its military capability, it is a noteworthy aircraft. ←→

Technical Data

Engines	
two Turboméca *Aubisque* jet engines, each delivering a static thrust of (no further data available)	1,540 lb
Main Dimensions	
Wing area	175 sq.ft.
Wing span	31 ft. 2 in.
Length	34 ft. 5 in.
Wheel track	6 ft. 7 in.
Wheel base	12 ft. 9.5 in.
Width of cabin (elbow level):	
front seat	4 ft. 0.8 in.
back seat	4 ft. 2.4 in.
Thickness/chord ratio (wing root)	10.3%
Thickness/chord ratio (wing tip)	12%
Weight	
net weight of airframe (including two normal pilot seats)	4,440 lb
takeoff weight (military trainer)	6,609 lb
fuel load: two-hour training flight	1,512 lb
maximum takeoff weight:	
CAR "acrobatic" category	7,700 lb
CAR "utility" category	8,140 lb
maximum landing weight, CAR	7,733 lb
ultimate load factor (military trainer)	11.0
Performance (at 6,620 lb takeoff weight)	
Takeoff:	
takeoff run	1,250 ft
takeoff distance to 50 ft	2,130 ft
balanced field length (engine failure)	2,890 ft
Climb (maximum thrust):	
sea-level rate of climb	4,700 ft/min
ditto, single engine	1,550 ft/min
climb time to 26,000 ft	8 min
service ceiling	43,300 ft
ditto, single engine	25,000 ft
Cruise (at 26,000 ft)	
max. speed	500 m.p.h.
max. continuous cruising speed	450 m.p.h.
normal cruising speed	400 m.p.h.
range at normal cruising speed	1,450 miles
endurance at normal cruising speed	3.8 hours
Landing:	
landing run	2,060 ft
landing distance from 50 ft	3,180 ft
stalling speed	95 m.p.h.

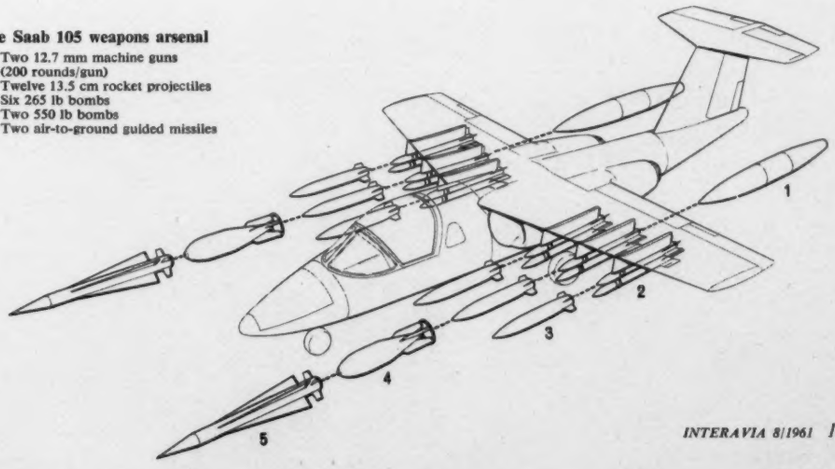
Five optional seating arrangements are available:

1. Two lightweight ejection seats; low-altitude ejection device can be installed.
2. Two fixed seats and a back seat for two or three persons.
3. Two fixed front seats and two back seats, all fixed.
4. Two fixed front seats, and a fixed seat plus a table with storage space at the rear.
5. Two fixed seats on the port side, and a stretcher on the starboard side.



The Saab 105 weapons arsenal

1 – Two 12.7 mm machine guns (200 rounds/gun)
2 – Twelve 13.5 cm rocket projectiles
3 – Six 265 lb bombs
4 – Two 550 lb bombs
5 – Two air-to-ground guided missiles



Vibration tests being carried out on a standard Beech D 18-S which has been modified for the installation of two *Bastan* turboprop engines in place of the usual Pratt & Whitney 985 piston engines. The modified aircraft is designated PD.18-9.

Conversion to Turboprops*

What, it is often asked, is the advantage of converting existing piston-engined aircraft by substituting turboprops or jet engines. Normally there are two reasons: either to flight-test a new engine on what actually constitutes a flying test bed, or to improve an existing airframe so as to render it more attractive to potential clients by providing it with a performance beyond the reach of its normal piston engines.

The problems arising in the first case are very different from those associated with the second; they hinge on the necessity for an engine installation which can power the aircraft. Experience has shown that, when an additional engine is mounted on an existing twin-engined or four-engine aircraft, thus converting it into a three- or five-engine craft, the reliability of the test results is insufficient for judging the engine's capabilities as a main source of power. These installations, while useful in the study of certain problems, such as de-icing, do not provide suitable test conditions, particularly for turboprops which require careful adjustment, and it is therefore necessary to mount the engine in an aircraft and utilize it as the powerplant. In general, when testing a new turboprop engine—to consider only this type for the moment—the first test installation should preferably be made on a relatively slow aircraft. In the case of the *Astazou* turboprop, for example, the initial trials were carried out in a Max Holste aircraft, which was actually the protoype of the famous *Broussard*. Risks are thus minimized, since slow aircraft generally have a short takeoff run, so that if a sufficiently long runway is used, several short hops are possible on the runway, and these is no need to risk engine failure while airborne over the surrounding terrain. Once satisfactory results have been obtained in this manner, i.e., when engine control problems at low takeoff speeds, and during approach and landing conditions, have been solved, a faster aircraft becomes necessary for studying a wider range of engine operation conditions. Only when these two studies have been completed can the engine be utilized for installation in an aircraft to be offered on the market.

As for the commercial advantage of these converted aircraft, mention has already been made of the improved performance due to the use of turboprops, which far surpasses that obtainable with piston engines; this may seem self-evident, but it is due to the favourable power/weight ratio of the turboprop, which is about double that of the piston engine, and to its diameter/horsepower ratio which is between a third and a half that of a piston engine of equal power. It is therefore possible, for a given weight and size of engine, to instal enough power to transform the aircraft completely. This being the case, it is evident that such conversions should be carried out only on airframes possessing an ample reserve of structural strength, and in many cases further reinforcement and modification will be needed to enable them to accept the enhanced performance. The results obtained during the last few years have shown that even relatively old aircraft—such as the Beechcraft 18, the prototype of which dates back to 1934—can be converted so as to utilize a new engine with twice the power of the original, provided certain precautions are taken. Not only must the airframe be fully proven throughout the whole of its flight regime, but the possibility of extending this range must also be checked. This can be accomplished in two ways, namely by aerodynamic wind-tunnel tests and by structural tests. The latter may include destructive static load tests, but must in any case include a vibration test of greater severity than any conditions likely to be encountered. In this connection, mention might be made of the interesting makeshift solution adopted for the *Beechcraft* when it was first being converted: since the engines were not ready in time, vibration testing was carried out by using in their place metal weights with exactly the same moments of inertia. Also, before the conversion is commenced, the airframe to be used should be thoroughly overhauled, unless it is new.

In carrying out the conversion, it is obvious that the fewer the number of parts to be changed, the lower will be the costs, and the more profitable the result. It is stressed that this type of conversion is worthwhile only if it yields a considerable improvement in performance, as the turboprop engine is a costly item. In the most favorable case, for an engine of a given power, the unit cost per horsepower of the turboprop engine is currently about two and a half times that of the corresponding piston engine. The turboprop should, therefore, be installed only in cases where a performance of the same order cannot be obtained with a piston engine. In particular, there is no point in replacing a piston engine of a given power with a turboprop only slightly more powerful, as the high cost involved would not be compensated for by the nominal performance increment; such a procedure is justified only when its purpose is engine testing and development.

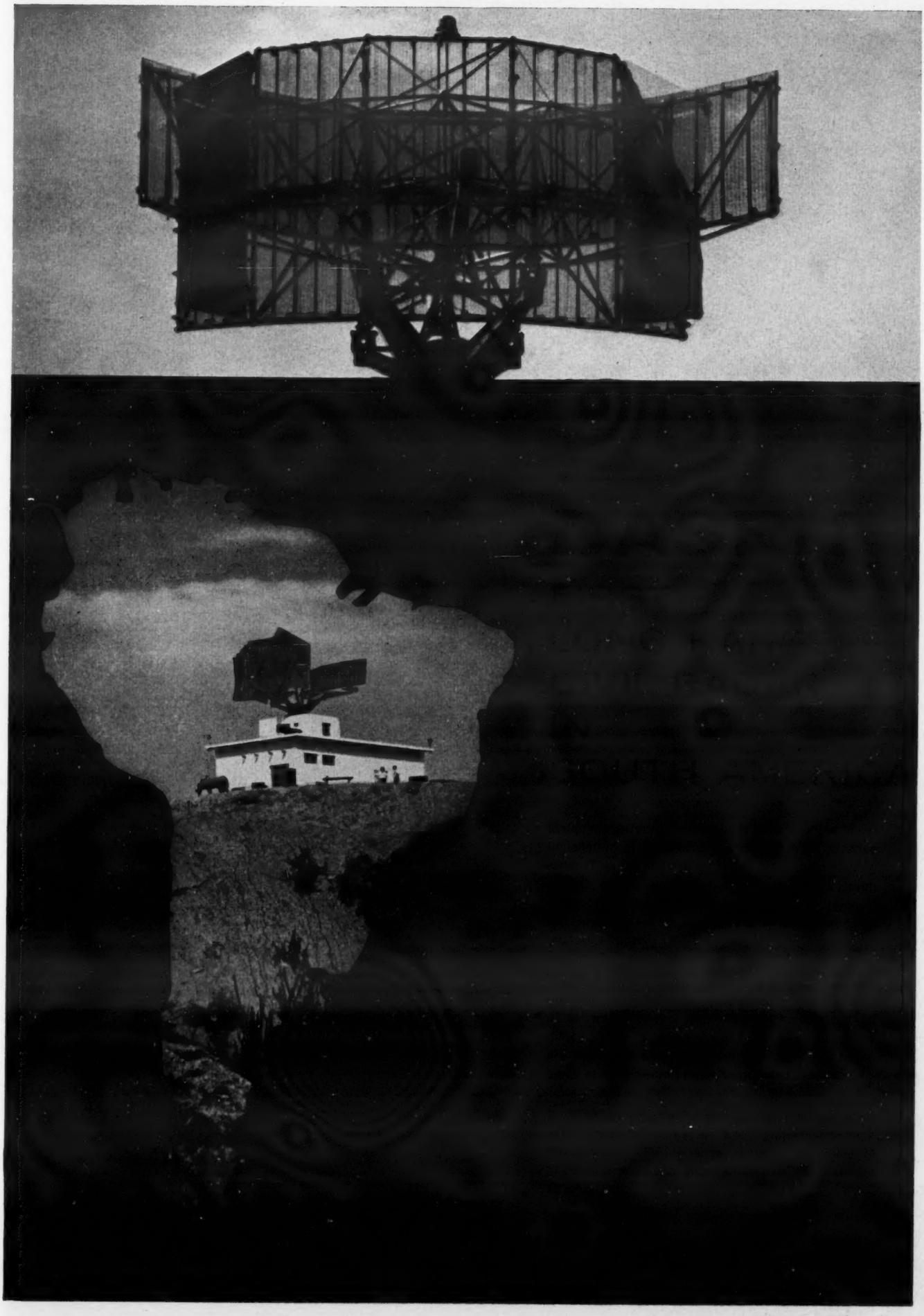
Apart from the engine cowling or nacelle, which must conform to the various detailed safety regulations established by international authorities, the main conversion problems are those involved in the modification of the instrumentation and circuitry, to meet the special requirements of turboprop engines. The range of the panel instruments must be extended to cover the increased performance. The fuel system requires complete re-design. The capacity of the fuel tanks must generally be increased and fuel line diameters must also be increased, at the same time providing more thorough fuel filtration than for petrol. Owing to the characteristics of kerosene, the slightest trace of moisture or other impurities in it results in filter clogging. In addition, extra-fine filters are needed to protect the high-precision fuel-metering units.

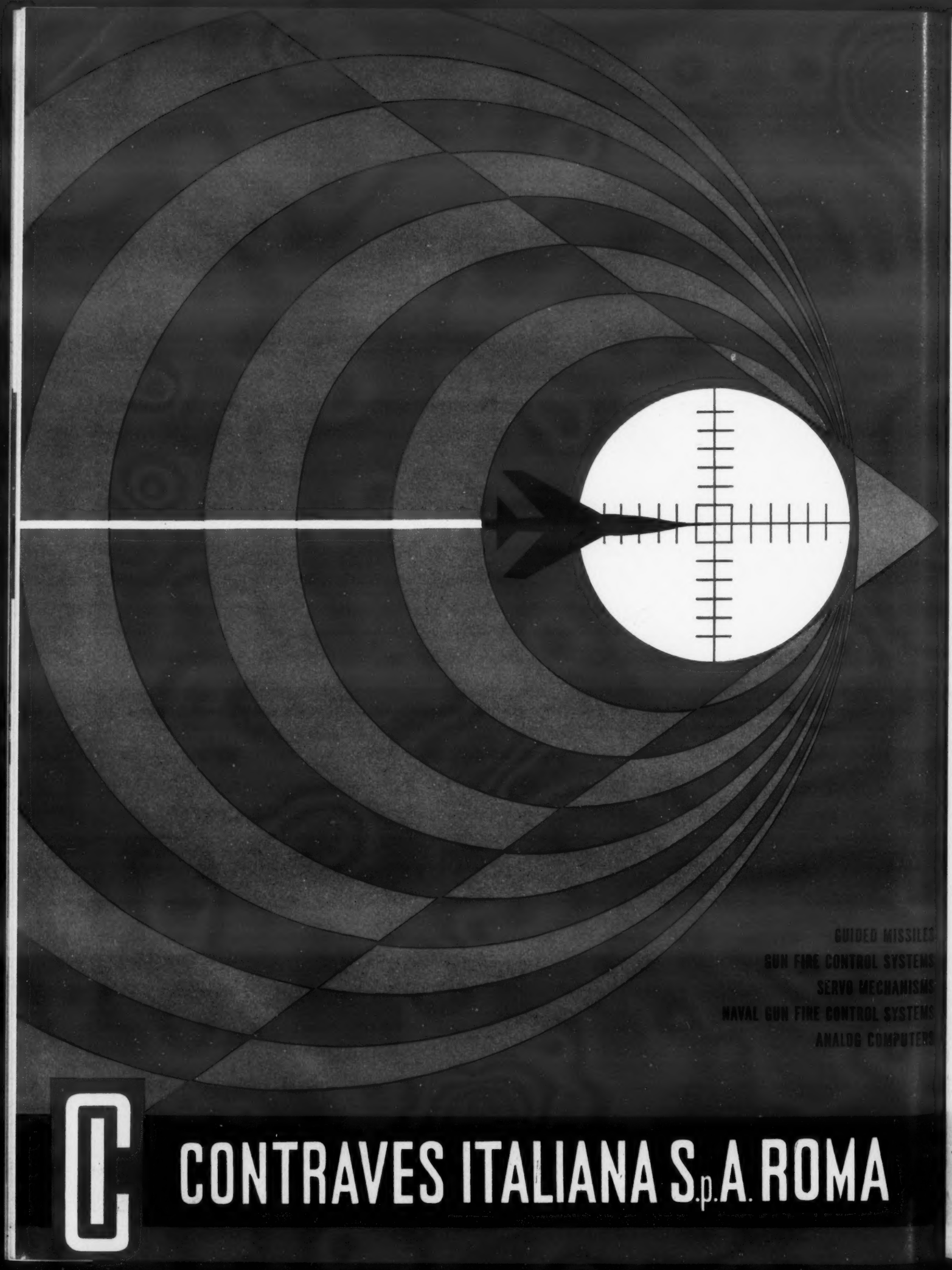
Despite the complication of these modifications, the improvement in aircraft performance is striking. Experience has shown that the speed of certain aircraft can be increased by 25, 50, and even 70 percent; the rate of climb, as well as the service ceiling, is generally doubled, while the takeoff run is sometimes halved. Finally, in the case of turboprops, a noteworthy improvement is the reduction in the landing run due to the ground fine pitch setting or pitch reversal of the propellers. This can be achieved without modification to the engine, and in particular with turboprops equipped with the new control device developed on the *Astazou*.

To sum up, it might be said that the conversion of piston-engined aircraft to turboprop engines is a delicate operation, and one which should only be undertaken after a careful study of the problems involved, in their technical and economic aspects. The results to be obtained, however, do provide a substantial reward for the effort expended. ⟿

* Article based on documentation supplied by the Société Française d'Entretien et de Réparation de Matériel Aéronautique (SFERMA).

The SFERMA/Beechcraft PD.146 *Turbo Travel Air* four seater touring aircraft is powered by two Turboméca *Astazou* turboprop engines, each developing 440 s.h.p. at takeoff. Cruising speed of the *Turbo Travel Air* is 260 knots. The standard Beech Aircraft Corp. *Travel Air* is fitted with two Lycoming 0-360 piston engines, each of 180 h.p.

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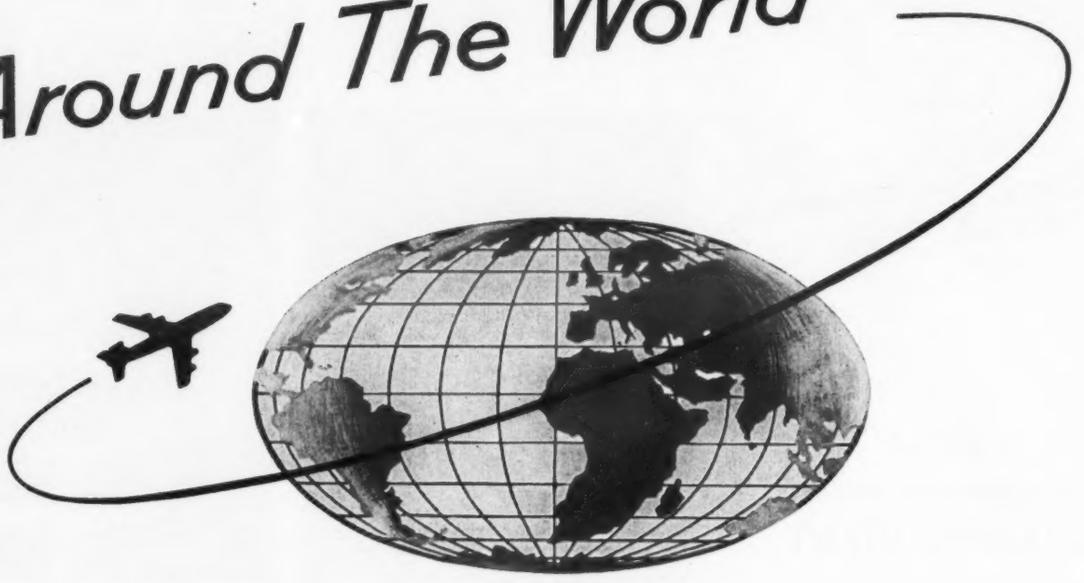

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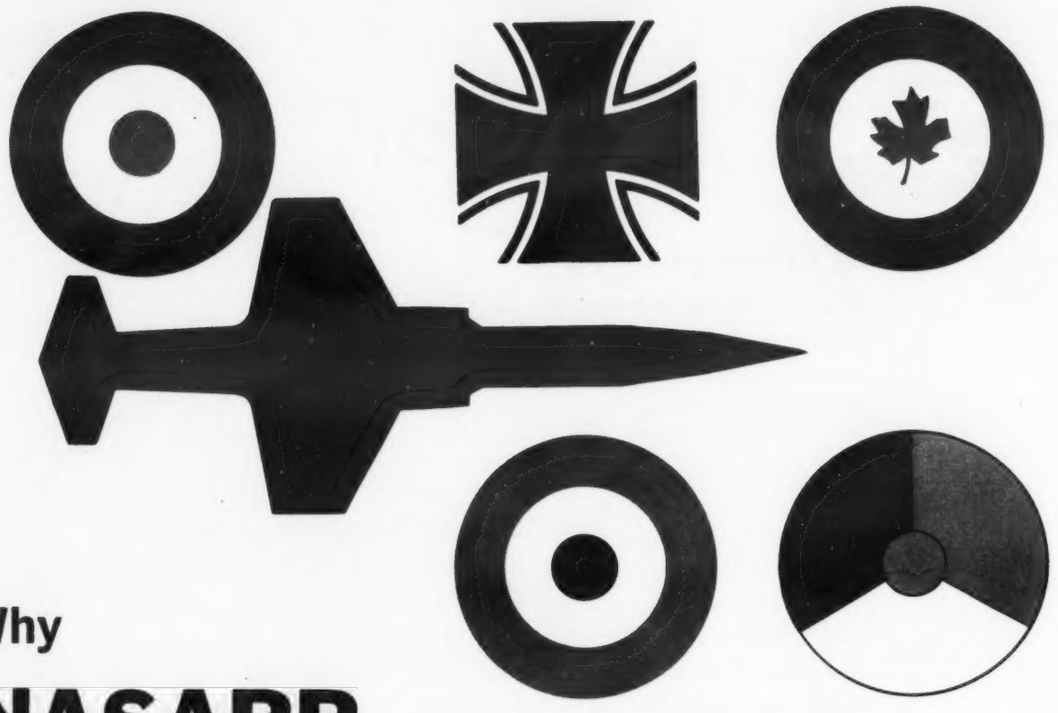

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Laminar Flow Control–

New Boundary Layer Studies at Northrop

Anyone who has followed the history of aeronautical science will quite often come up against the paradox that practice has been years ahead of theory. In other words, the constructors followed the right road, either by instinct or by chance, and took advantage of aerodynamic phenomena; it was only later that the scientists came along with reasoned explanations. The Wright Brothers, for example, as well as Farman and Blériot, made their first hops before one could even speak of any adequate theory of airfoil lift.

These exceptions however only go to confirm a rule which is becoming more and more valid as aircraft increase in complexity, namely that every design is based, often down to the last detail, on extensive theoretical investigations and laboratory tests. And in aerodynamics, as is so often the case with the natural sciences, enough instances can be given of practicable ideas which were far ahead of their time and which it took years, or even decades, to transform into reality.

The idea of reducing aircraft drag by sucking off the boundary layer comes into this category. As early as 1904, Ludwig Prandtl in Germany succeeded in removing the boundary layer in a cylinder by suction through a slot into the interior, thus achieving a major reduction in air drag. Although the idea of applying the same principle to aircraft must have been obvious from this experiment, over 20 years in fact elapsed before the first airfoil sections, incorporating the suction principle, were tested; flight tests did not begin in Germany until the thirties, these being continued until the end of World War II. Apart, however, from some research aircraft, the knowledge gained did not lead to any practical result.

Whilst most of this work was directed mainly to raising the lift coefficient, and thus shortening takeoff and landing distances, interest developed in Great Britain and the USA after the war in the reduction of aircraft drag through boundary layer control. At Handley Page, under the scientific direction of Dr. Gustav Lachmann, various projects came into existence and, on the other side of the Atlantic, Dr. Werner Pfenninger at Northrop continued the research started by Prof. Ackeret at the Aerodynamics Institute, Zurich. This work, which had the support of the US Air Force, found its expression in a series of publications, but it was not until this year's Paris Air Show that Northrop presented the latest results to a wide public. A fortnight later, at a Joint Meeting of the Institute of Aerospace Sciences, and of the American Rocket Society, a paper was read on the same subject*.

Why boundary layer suction?

In subsonic flight, the drag of an aircraft comprises induced drag and parasite drag. The latter can again be divided into structural drag and friction drag. Structural drag is to be seen as the resultant of air loads acting vertically to the surface, and friction drag as the resultant of air loads acting parallel to the surface. In the sonic barrier and supersonic ranges, these are joined by shock (or wave) drag, which is the result of compression created by the aircraft itself.

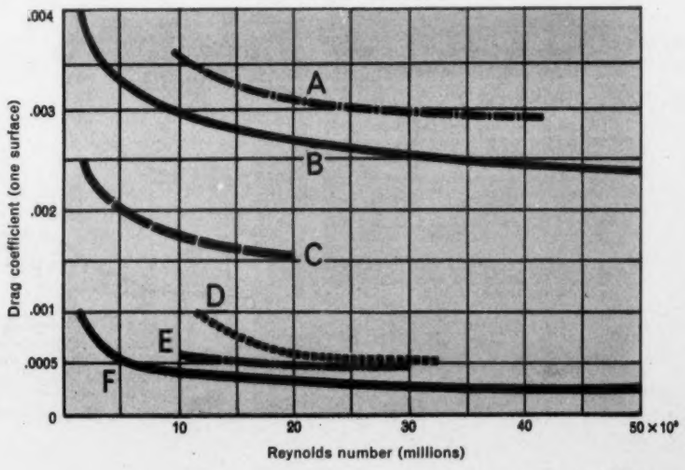
* Welko E. Gasich, Northrop Corporation: "Application of Laminar Flow Control to Transport Aircraft."

Whereas induced drag is directly connected with lift—and to some extent represents the minimum price which must be paid for flight capability—parasite drag has, as the name implies, no "useful" value. It is not, therefore, surprising that the efforts of constructors have, from the beginning, been directed to minimizing such drag. And, although improvements continued to be achieved by refining shape and by a high degree of surface smoothness, sudden change of the boundary layer into the turbulent state could not be avoided. The last decade has gradually seen the limit of possible advance in this direction on the basis of "traditional" methods, and only laminarization of the boundary layer now promises real progress.

As a first step in this direction, a start was made in World War II on the development of so-called laminar sections, in which the boundary layer remains over a large part of the wing chord, thanks to the fact that the maximum thickness lies relatively far back, but the boundary layer nevertheless does become turbulent and finally breaks down. Complete laminarization of the flow can, however, be achieved only by continuous suction of the boundary layer over the entire wing chord. The effect here is a double one—structural drag is reduced, since no separation takes place, and friction drag of the laminar boundary layer is considerably less than that of the turbulent boundary layer *(Fig. 1)*.

A high maximum lift coefficient arises as, so to speak, a by-product, since the flow is not separated until a correspondingly higher angle of attack is reached. If this high lift coefficient, and not reduction of drag in cruise flight, is the criterion, blowing out of compressed air on the upper wing

Fig. 1: This diagram shows the considerable reduction in profile drag obtainable through laminarization. Curve *B* shows friction resistance of a smooth surface turbulent flat plate (according to von Karman) and curve *F* of a laminar flat plate (according to Blasius)—both these are theoretical. As compared with a typical series-production wing (curve *A*) profile drag can be cut down to half by polishing the surface (curve *C*). Curve *D* shows results with an F-94, whose wings were modified on the upper side and provided with 69 suction slots. The boundary layer remained laminar up to the maximum Reynolds number reached (36×10^6). Still more favourable results—particularly in the case of low Reynolds numbers—were obtained in wind tunnel measurements of a wing with 30° sweepback (curve *E*), the boundary layer also being removed by suction. In the case of curves *D* and *E*, the suction energy required is included.



surface has preference, in that it is simpler from the technological point of view. Some carrier-based naval aircraft (for instance the Blackburn NA.39 *Buccaneer*, the McDonnell F4H *Phantom II*, and the North American A3J *Vigilante*) already utilize this method and, with the increasing interest in STOL transports, similar solutions are also featured in long-haul aircraft (the Lockheed boundary layer control *Hercules*).

High surface quality

As has already been shown for laminar profiles, a high surface quality is indispensable for maintaining the laminar boundary layer. *Fig. 2* shows the maximum tolerances calculated at Northrop for swept wings and high subsonic speeds. Modern manufacturing processes enable these demands to be fulfilled without difficulty. Where there is danger of buildup, e.g. at the junction of two skin plates, care must be taken to ensure that the edge is "positive" i.e. projected into the flow (see *Fig. 2*, case *C*).

The "suction wing", however, differs radically from the conventional wing not only in respect of surface configuration, but also in structure. In order to be able to lead off the air removed by suction without too great loss of pressure, the channels must be wide in section.

As can be seen from *Fig. 3*, Northrop is proposing a wing in which the whole wing section, with the exception of the central part reserved for the ribs or fuel tanks, is available for ducting air. In the part lying between the two spars, the wing profile is very plane, with the result that quite small amounts of sucked air are sufficient to maintain the boundary layer

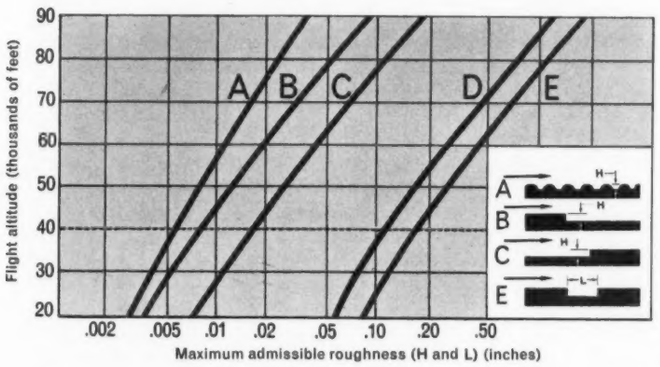


Fig. 2: An indispensable condition for low friction drag—even when boundary layer is removed by suction—is a smooth wing surface. The diagram shows maximum admissible roughness for a subsonic swept wing aircraft. Since the kinematic tenacity of the air increases as density decreases, less and less surface smoothness is required as altitude increases. The broken horizontal line designates average cruise altitude. Curve *A* represents surfaces with irregularly distributed roughness, curve *B* a downstep spanwise and curve *C* an upstep spanwise. There should be no difficulty in maintaining chordwise (curve *D*) or spanwise (curve *E*) gaps less than 0.1 in. wide.

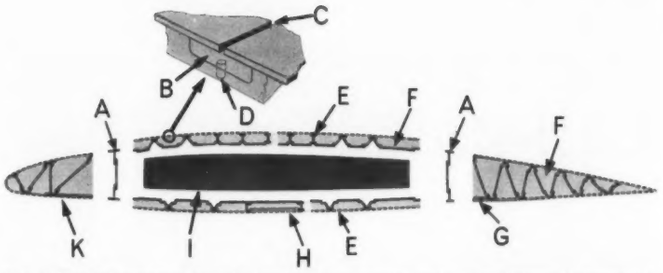


Fig. 3: Typical construction of a laminar flow control wing. The distance between the slots is less near the maximum thickness point than at the nose and trailing edge section (not visible on the diagram). A – spar; B – plenum chamber; C – suction slot (.005 to .010 in. wide); D – slot connecting plenum chamber with air ducts below; E – skin panel; F – air duct; G – removable panel for spar inspection; H – removable panel giving access to fuel bay; I – fuel bay; K – removable panel for inspection of controls, also of hydraulic and electric fittings.

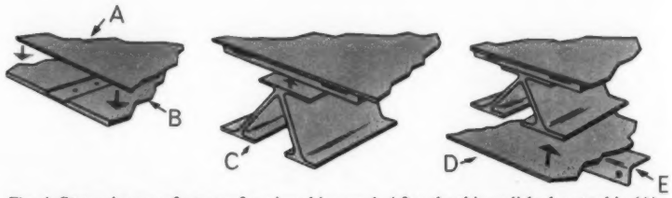


Fig. 4: Stages in manufacture of a wing skin panel. After the thin polished outerskin (A) and the milled structural skin (B) have been bonded together, the stringers (C) are bonded to the outer skin assembly. Lastly, the inner skin assembly (D), complete with bonded rib attachment (E) is bonded to the stringers.

laminar. At the wing nose and at the trailing edge, on the other hand, more slots are necessary, as the spacing between them is smaller. In the centre, the distance between slots is some 2 in.

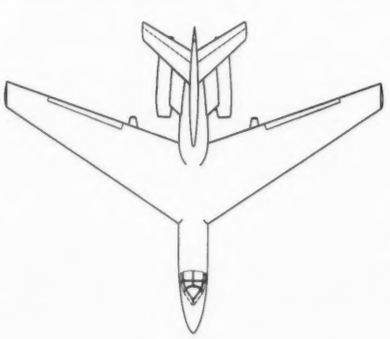
In order, on the one hand, to ensure a smooth surface and, on the other, to keep production costs as low as possible, Northrop makes plentiful use of bonded metal in the wing. All external components are bonded, rivets and bolts being used only at the final assembly stage. The individual operations in the assembly of the main components can be seen from *Fig. 4*. In bonding, the outer skin is pressed on to a thick aluminum plate, the surface of which has been precision-milled by means of a numerically controlled milling machine, so that the accuracy of the wing surface is guaranteed to two-thousandths of an inch.

When the skin sections are ready, the slots are then cut on the upward movement of the saw blades (from the interior to the exterior), so that burrs cannot form on the inside edges of the slots.

As far as maintenance of the "sensitive" suction wing is concerned, Northrop estimates that 3.53 additional manhours per hour's flying are

Fig. 5:

Overall length of aircraft	76 ft
Wing	
Span	93.5 ft
Area	1,250 sq.ft
Aspect ratio	7.0
Sweepback at 1/4-chord	30°
Taper ratio	0.3
Thickness ratio	0.1
Dihedral	—2.0°
Engines	Two General Electric JE-J79-GE-3A
Gross takeoff weight	83,000 lb.

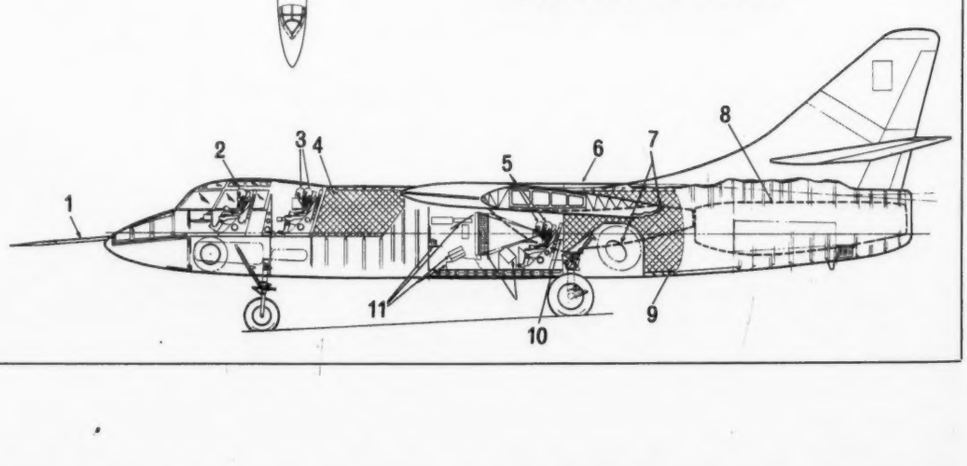


The Norair Division of the Northrop Corporation is at present converting two B-66s into research aircraft for laminar flow control tests. First flight is expected to take place in January, 1963.

Fig. 6:

Cutaway view of the B-66

1. Nose probe;
2. Pilot;
3. Flight observers;
4. Fuel tank;
5. Flight test engineers monitoring the boundary layer suction system;
6. Suction duct fairing leading to the tail assembly;
7. Outline of the suction fan nacelle;
8. Outline of the engine nacelle;
9. Fuel bays;
10. Shelf for camera recorder;
11. Instrumentation.



necessary: 56 percent of this extra time is accounted for by the airfoil surfaces (inspection, cleaning, and repair), 38 percent by the moving parts of the suction system, and 6 percent by the monitoring instruments. Since 15 man-hours maintenance per flying hour is required for the jet transports at present in service, the additional time in the case of aircraft with boundary layer control amounts to 23 percent. If, however, total maintenance costs are taken as the basis of comparison (these, of course, include the materials used) the difference would come down to 9 percent, which is more than compensated for by the advantages in operation.

Two research aircraft in construction

After having undertaken basic flight tests with a modified F-94A as early as the mid-fifties—the results are illustrated by curve *D* at *Fig. 1*—the Norair Division of the Northrop Corporation was given a contract by the U.S. Air Force in August 1960 for the conversion of two Douglas B-66 *Destroyers* into research aircraft. The B-66 was selected because its size and speed are equivalent to a modern jet-powered transport and about the same Reynold's number range can be flown. As our box shows, however, little remains of the original version. Completely new wings, with a 60 percent greater area, are being constructed in accordance with the processes described earlier, the engines are being installed at the rear of the fuselage, and the suction fans lodged in two nacelles under the wing (see *Fig. 5, Fig. 6,* and the drawing at the head of this article).

The reason for placing the engines at the rear of the fuselage was to enable experiments on the wing to proceed undisturbed, although Northrop gives the assurance that engines can also be fitted under a suction wing.

The main intention underlying this research programme is to test the practicability of this concept under real conditions and, at the same time, to obtain experience as a basis for series construction. It is hoped that the research being undertaken will yield answers to such questions as:

- Can the required wing surface smoothness be achieved in production and maintained in operation?
- How does the wing, based on an entire new structural concept, behave under dynamic stresses (fatigue resistance)?
- Given the present state of production techniques, can suction wings be series-built at an acceptable cost?
- Can laminarization of the boundary layer be assured in the case of heavy showers, dirty atmosphere, and other unfavourable operational conditions?

Detailed drawings of the wing are already in existence and the final production installations are at present being constructed. The timetable calls for the first of the two research aircraft to leave the factory in October, 1962 and to start flight testing in January, 1963.

What are the operational benefits of laminarization?

The question now arises as to the effect of boundary layer suction on the main design parameters. To give one example, theory shows that, at constant gross weight or takeoff weight, the optimum wing area (i.e. optimum as regards overall drag) is larger in a case of a "laminarized" than in the case of a "turbulent" aircraft. Given constant takeoff weight and aspect ratio, induced drag decreases as wing area increases. On the other hand, friction drag increases proportionally to increases in area, although less when the boundary layer is laminar than when it is turbulent. The result of this is that the laminar aircraft attains its optimum lift/drag ratio when wing area is large, and that this ratio is half as much again as for a conventional aircraft with the same takeoff weight and the same wing aspect ratio.

As far as the proprietor of the aircraft, especially the airline operator, is concerned, these aerodynamic details are of much less interest than the flight performance and operating costs of his machine. It is, therefore, understandable that, in addition to research into the quality of laminar aircraft, Northrop has made detailed cost analyses which, if we may anticipate, are more than encouraging. Some of these results are reproduced at *Figs. 8—11*.

Taking as a basis a normal payload of 50,000 lb. (for design range), a maximum payload of 70,000 lb (with reduced available fuel), and a cruising speed of Mach 0.8, one arrives at the payload vs. range diagram in *Fig. 8*. Each of the two curves represents a series of aircraft with each aircraft optimized for maximum range for the weight shown. Critical field length in no case exceeds 10,000 ft, and all calculations have been made on the basis of two jet engines with a thrust/weight ratio of 4.25 and specific fuel consumption of 0.78 lb/lb/h—assumptions which can be considered more than conservative. *Fig. 8* speaks for itself; at a takeoff weight of 250,000 lb, the gain in range as a result of boundary layer suction is no less than 60 percent. In view of this diagram, it is hardly surprising that the US Air Force is showing considerable interest in the laminar flow control concept. In the case of a patrol aircraft, boundary layer suction could lead to a degree of independence hitherto unknown and enable an aircraft of this kind to reach practically every strategically important point in the world in non-stop flight from American bases, without the necessity for re-fuelling in flight, which is always costly in time and money. It is much the same in the case of

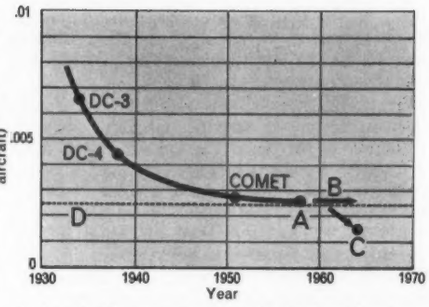


Fig. 7: Whilst in the past it was possible continually to reduce the skin friction coefficient of aircraft as a result of advances in aerodynamic knowledge and improvements in production processes, further progress has now become impossible with conventional means, and only laminar flow control can bring renewed progress.

A – A typical jet transport with turbulent boundary layer; *B* – The trend without laminar flow control; *C* – The trend with laminar flow control; *D* – low limit for friction drag of jet transports with turbulent boundary layer.

The effect of boundary layer characteristics on the profitability of commercial transport aircraft (LFC = laminar flow control).

Fig. 8: At identical takeoff weight, a 60 percent gain in range or, at identical range, 18 percent less takeoff weight.

Assumptions: Payload 50,000 lb.
Critical field length 10,000 ft.
Cruising at Mach 0.8.

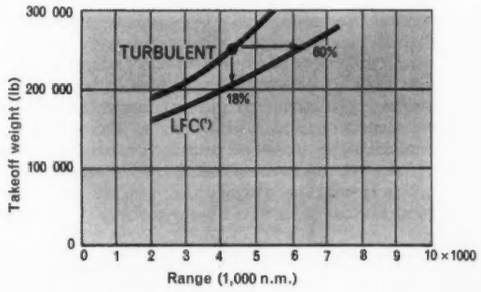


Fig. 9: As range increases, the difference in direct operating costs becomes appreciably larger. In all cases, payload is the same (50,000 lb). The thin lines refer to takeoff weight.

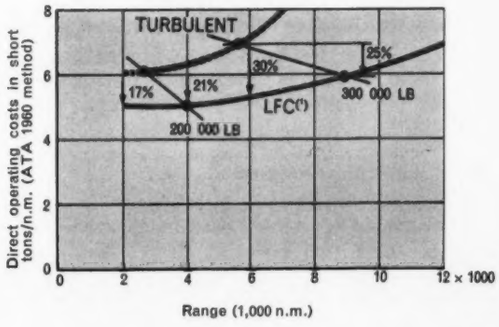


Fig. 10: Payload vs. range diagram for cargo jet with max. takeoff weight of 267,000 lb and a cruise speed of M 0.8. The dotted curve relates to a turbulent boundary layer and the heavy curve to a laminary flow control. In both cases, critical field length is 6,000 ft. The black dots indicate the military requirements (SOR-182 specification).

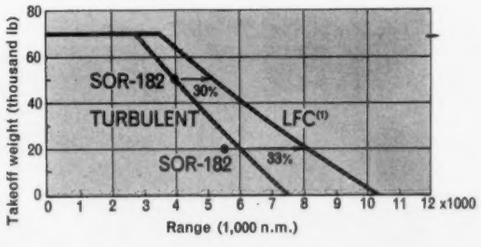
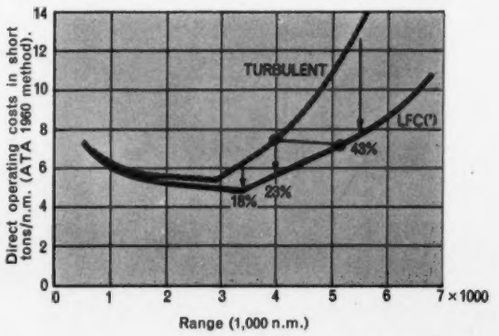


Fig. 11: Comparison of direct operating costs at fixed takeoff weight of 267,000 lb. The two large dots correspond to a payload of 50,000 lb.



operational costs *(Fig. 9)*. Even in the medium-haul range, the difference between laminar and turbulent aircraft is interesting from the economic point of view, even after allowing for the fact that each point on the two heavy curves is based on optimum engines.

In order to get away from an accumulation of optimum conditions, comparative calculations have been made on the basis of "tangible" projects. *Figs. 10 and 11* deal with an example of this kind. The US Air Force, in its specification SOR-182, calls for a jet-powered freighter capable of transporting a payload of 50,000 lb over a distance of 4,000 n.m. or 20,000 lb over 5,500 n.m. at a flying speed equivalent to Mach 0.8. In both cases, the critical field length called for is 6,000 ft. The curves marked TURBULENT in these two diagrams refer to a design submitted against this specification which is based on a takeoff weight of 267,000 lb. The aircraft with laminar flow control (LFC) has the same fuselage but a 44 percent larger wing (4,000 sq.ft as compared with 2,800 sq.ft), enabling the takeoff requirements to be fulfilled—this despite the lower-powered engines, which are adequate for Mach 0.8 owing to the lower drag in cruising flight. There is a substantial gain in range, namely 30 percent at a payload of 50,000 lb and 33 percent at 20,000 lb.

In the comparison of costs shown at *Fig. 11*, some typical operational distances are highlighted. Whereas, at the trans-Atlantic or Hawaii—Japan distance of 3,500 n.m., the LFC aircraft works out 18 percent cheaper, at 4,000 n.m., the difference in direct operating costs reaches 23 percent, and at the Los Angeles-Paris distance of 5,500 n.m. amounts to as much as 43 percent. In addition, *Fig. 11* brings out another essential basic fact, namely that an existing aircraft equipped with laminar wing and tail assembly would be able to operate over a broad spectrum of ranges at relatively low operating costs; although at distances below that which can be attained at maximum payload the gain is rather small, it thereafter increases all the more steeply. The profitability of this aircraft would, therefore, be less dependent on the length of route or, in other words, a commercial operator could work the most varied routes with the same type of aircraft; this would not only enormously simplify route planning but would also lead to substantial economies in maintenance and in the procurement of spares.

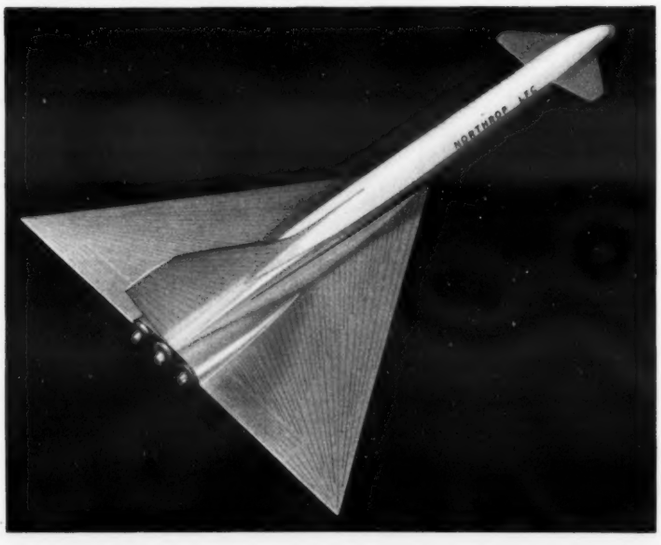
The outlook for the future

Although Northrop engineers admit that the operational LFC aircraft may still be a long way off, they are already thinking about future development. At first, laminar flow aircraft should not be expected to differ much in configuration from their "turbulent" sisters; later on, however, they will have more and more features of their own, for instance:

- as a result of reduced friction, induced drag becomes more evident, which is an incentive to developing wings of greater span, whilst retaining present structure-weight efficiencies;
- further aero-dynamic clean-up becomes worthwhile (for example smoother windshields, fewer bumps and fairings, lower interference drag, and more highly streamlined bodies);
- further reductions in friction drag will become possible by the application of LFC to the fuselage and other sources of "turbulence".

Under an US Air Force contract, Northrop is currently investigating laminar flow on various bodies, including bodies of revolution. Wind tunnel tests at high Reynold's numbers should help to clarify whether boundary layer suction is also practical in the case of bodies. If, for example, one could also extensively laminarize not only the wing and tail assembly but also the fuselage and engine nacelles of the jet transport indicated by a heavy black dot at *Fig. 8*, it would be possible to increase range by 85 percent.

Fig. 14: Model of a M 3.0 transport (canard type) with laminar flow control. To show the suction slots, they have been drawn larger than scale.



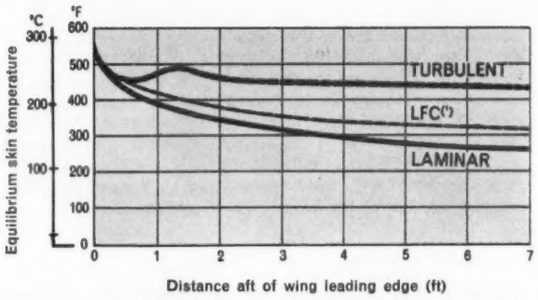


Fig. 12: Owing to reduced surface friction, the outer skin of the wings gets far less hot in the case of the laminar flow than in the case of the turbulent boundary layer. The two bold curves show the flat plate theory as applied to turbulent and laminar boundary layers respectively, the dotted curve shows laminar flow control. In all cases the speed of the undisturbed flow is equivalent to M 3.0.

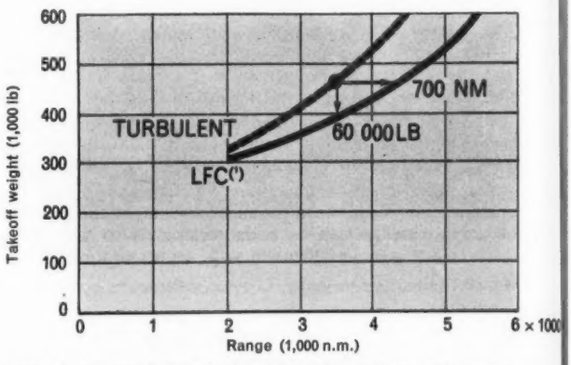


Fig. 13: Even in the case of a supersonic aircraft, the additional expenditure of boundary layer control is worthwhile. Both curves refer to the same payload and a cruise speed of M 3.0.

Even for supersonic aircraft LFC would pay

If, because of additional wave drag, laminarization of supersonic aircraft does not promise the same reduction in total drag as in the case of subsonic aircraft, it is nevertheless advantageous in another way. As a result of the lower mean velocity gradient in the laminar boundary layer, the convective heat transfer is reduced, thus giving appreciably lower skin temperatures, a fact of perhaps decisive importance (see *Fig. 12*). In case of the LFC wing, surface temperature is slightly higher than would be the case with "natural" laminar flow. In comparison with the "turbulent" wing, however, there is still a difference of about 50°C. In other words, in the case of a Mach 3 aircraft, surface temperature could be held below 180°C, with the result that it would be no longer absolutely essential to build in steel. Apart from the further reduction in drag, boundary suction on the fuselage could also considerably relieve the load on the air-conditioning system.

As can be seen from *Fig. 13*, even laminarization confined to the wing and tail assembly shows very promising results. The heavy black dot corresponds to a design which was presented a few months ago at the IATA Symposium on supersonic transport. At the same maximum takeoff weight, laminarization of wing and tail assembly would increase range by 700 n.m. Alternatively, at an unchanged range of 3,500 n.m., takeoff weight could be reduced by 60,000 lb. Quite apart from the reduction in operating costs, the reduction in weight would bring a number of other advantages, such as less demand on the strength of runways and taxiways; lower takeoff and landing speeds, which do not significantly exceed those of current jet transports; and, last but not least, a reduction in sonic boom as a consequence of the lower wing loading.

Although these results, derived partly from theory and partly from experiments, may well justify high hopes, it would be premature at this stage to predict a revolution in air transport or to write off the "turbulent" aircraft.

Northrop had good reasons for completing 12 years of intensive research before making any concrete design proposals public, and painstaking work is still needed to bridge the gap between the laboratory and the operational aircraft. We are, therefore, entitled to look forward with great interest to the first results which the two research aircraft will yield, since the flight tests in question should have a decisive influence on the course of future developments. If the results are positive, and so far there is no reason to believe the contrary, there should be a great future for the principle of laminar flow control. ←

A British Contribution to Boundary Layer Control

Handley Page Projects

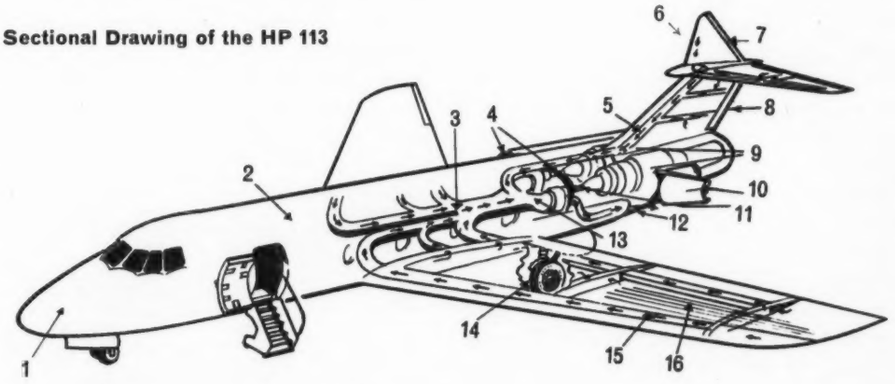
After years of work devoted to boundary layer control questions—at first mainly on increasing lift by means of slat sections and later on the laminarization of wing flow through suction of layers adjacent to the wing surface—Handley Page Ltd. is now developing a research aircraft, designated HP 113, in order to obtain the necessary basic experience under real operational conditions.

As early as 1953, flight tests undertaken with a modified de Havilland *Vampire* yielded very promising results, wing boundary layer control enabling friction drag to be reduced by as much as four-fifths. This success was the incentive for various projects in the ensuing years; however, in the absence of government support, these did not progress beyond the design stage. Such projects included a long-haul transport for 120 passengers, an executive aircraft for 12 persons (developed from the HP 113), and the daring project of a tailless aircraft, which would be capable of carrying 300 passengers over trans-Atlantic distances at a high subsonic speed. According to calculations made by Handley Page, operating costs for such an aircraft would be so low that a passenger could buy a ticket from London to New York for only £11 sterling.

Dr. Gustav Lachmann, Head of research at Handley Page, has in numerous lectures and articles emphasized the potentialities of laminar flow control. Whilst the work being done in other countries relates mainly to slot suction, studies in England have also covered the use of porous wing surfaces, by means of which suction can be made practically continuous, i.e. uniformly spread over the surface. This is of particular importance in the area of the nose of the wing (edges, which are unavoidable in the case of slits, cause disturbances which favourize a sudden change of the laminar flow into the turbulent state). For instance, the first of the projects mentioned above foresaw the use of porous steel at the wing leading edges. Over the remainder of the wing it has been planned to have slots .005 in. wide extending over the entire span at right angles to the direction of flow. Since it is very difficult to eliminate the sudden change of the thin laminary layer at the trailing edge of the wing, i.e. at the nose of the flaps and ailerons as well as at the air brakes, it was planned to remove the entire boundary layer by suction through the slot, so that a new boundary layer can form on the control surfaces. This boundary layer is again maintained in a laminar state by slit suction. An alternative solution considered was suction by means of perforated strips, and this has already been the subject of tests on the *Vampire* wing.

Optimum arrangement of the suction slits alone is, however, not the whole story. Apart from the suction fans themselves, the constructor is faced with the difficult problem of reconciling minimum flow losses in the ducting with adequate wing strength. A laminarized aircraft can be used for regular services only if the suction system works perfectly in all conditions which can be expected to arise in operation. And it should be less difficult to achieve accurate and responsive fan performance i.e. adaptation to the changes in flow conditions (such as air density, angle of attack, and flight speed) than to prevent the tiny slots on the upper surface of the wing from collecting dirt. In this connection, scientists are particularly concerned about insects which, when they strike the upper surface and adhere to it, not only cause surface roughness and thus set up local turbulence, but also threaten to clog the narrow suction channels. Dr. Lachmann has already often let it be understood that, at times, his activity has borne more resemblance to that of an entomologist than to that of an aerodynamicist. All the same, the main difficulties have been successfully overcome and the proper shape and distribution of the slits and incisions established. Last year, flight testing of a research wing mounted on a *Lancaster* began. As already mentioned, the HP 113 research aircraft is expected to yield further information.

Sectional Drawing of the HP 113



1 – directional radar;
2 – pressurized cabin;
3 – central duct to suction pump;
4 – engine air intakes;
5 – sucked air from tail unit;
6 – all-moving high tailplane;
7 – narrow elevators;
8 – rudder;
9 – two Bristol *Orpheus* jet engines;
10 – air brake;
11 – shaft-drives from engines to pumps;
12 – suction air outlet;
13 – suction pump;
14 – landing gear, retractable into fuselage;
15 – sucked air from wings passing along ducts;
16 – suction slits.

Drawing of the HP 113 research jetliner with laminar wing surface and tail assembly flow. Design data: length 71.6 ft; span 71.4 ft; weight 36,300 lb; cruising speed 530 m.p.h.

In 1960 at Farnborough, Handley Page showed this model of the HP 117 tailless large transport for 300 passengers, the entire upper surface being laminarized.

Over and above this subsonic development programme, Handley Page has for some time been conducting investigations into laminarized supersonic flow. However, research projects as ambitious as this require the allocation of funds on a scale beyond the resources of one firm on its own. Should the investment to date in both money and mental effort one day bear fruit, the only basis for pursuing this development—unless Government assistance is forthcoming from military motives—would be by cooperation with a large and financially strong concern. ⟶

Wag Tail

An Air-Launched Rocket for Use Against Air and Ground Targets

In an article, which was published in *Interavia* No. 7/1961*, concerning a completely integrated weapons system for VTOL aircraft, reference was made to the use of an air-launched missile which could be delivered from an aircraft flying on a course which lay at some offset distance from the target.

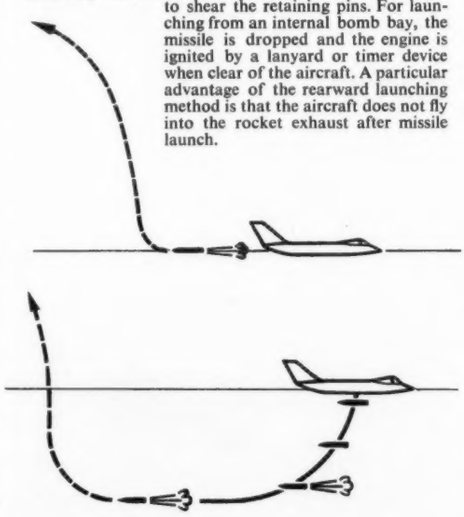
This concept of providing the tactical aircraft with a standoff capability has grown in importance with military planners in recent years. Considerable research has been devoted to methods of bomb delivery using conventional free-falling weapons and this has resulted in the development of techniques such as loft and toss bombing. The main disadvantage of these systems is the necessity for the aircraft to fly a precisely programmed manoeuvre and to approach near to, or even fly over, a heavily defended target. The existence of a tactical weapon which would provide this standoff capability is of major interest to military Staffs, and it is known that the NATO powers are particularly anxious to provide this capability for the next generation of tactical aircraft.

The *Wag Tail,* an inertially guided missile developed by Minneapolis Honeywell, is a weapon which fulfils this requirement. The origin of the *Wag Tail* stems from a series of studies and investigations conducted by the United States Air Force. The requirement for a new generation of tactical and strategic missiles had been underlined by operational research into the growing effectiveness of ground defences and the increased vulnerability of the attacking aircraft when in the target area.

In order to reduce the hazard to the aircraft, the intention was to develop a missile which did not rely upon gravity drop or command guidance for delivery. As this concept pointed to an inertially guided weapon being the most satisfactory solution, the Minneapolis Honeywell company was selected as the prime contractor in view of the company's long experience in gyro techniques.

The missile configuration

Before describing the operational applications of *Wag Tail,* a few descriptive details of the missile itself will illustrate some features of the new concept. The weapon is an air-launched rocket-powered missile, light enough to be carried by tactical strike aircraft, and guided by a simplified inertial system. As can be seen from the diagrams, the design consists of a number of packaged sub-systems which are interchangeable to ensure maximum serviceability. The sealed liquid-propellant rocket engine gives two levels of thrust, the first high power phase for launch and initial manoeuvre and the second level for terminal manoeuvre. Carbon jet vanes in the rocket efflux, which are actuated by servos controlled from the inertial guidance system, direct the thrust vector of the rocket.



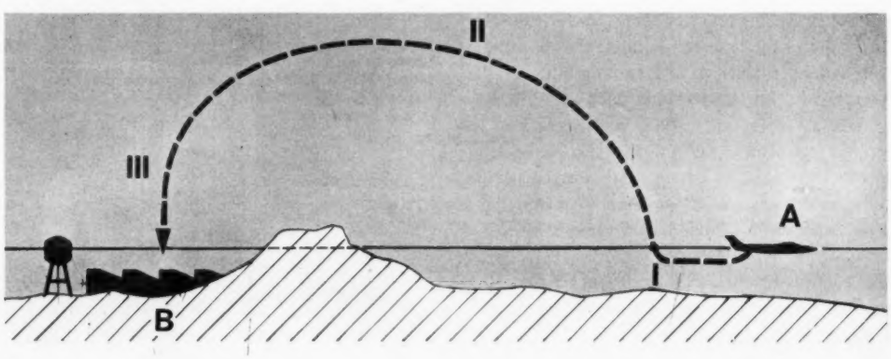
Two methods of launching a rearward firing weapon. When suspended from an under-wing pylon, the missile engine can be ignited, and the missile will leave the launching rails as soon as sufficient thrust is developed to shear the retaining pins. For launching from an internal bomb bay, the missile is dropped and the engine is ignited by a lanyard or timer device when clear of the aircraft. A particular advantage of the rearward launching method is that the aircraft does not fly into the rocket exhaust after missile launch.

The guidance sub-system, as developed by Honeywell, is a three-axis, local-vertical, north-oriented platform with three miniature integrating gyros and two accelerometers. In flight and prior to the moment of the launch, the platform is kept continuously aligned by means of inputs from the gyro-compass and from velocity data from the master inertial system on board the aircraft.

After launch from the aircraft, the missile is directed into a near-vertical climbing trajectory by means of the jet vanes. These vanes provide full control at all altitudes, as there are no dynamic pressure limitations, and they give rapid and large angle manoeuvreability in excess of that afforded by conventional aerodynamic control surfaces. During the climb, the guidance system positions the missile so that its path will result in a ballistic trajectory to the target after burnout of the high-power rocket phase. During the mid-course flight, pop-out fins stabilize the missile aerodynamically, and on arrival over the target the second stage engine ignites and the jet vanes perform the terminal manoeuvre which directs the missile into a vertical descent onto the target.

A particularly interesting feature of the *Wag Tail* is the method of launching. The missile is carried on the aircraft in a tail-first position and on firing is launched rearward. This scheme obviates the aircraft flying into the rocket exhaust and shockwave, which may result in engine compressor stall and similar malfunctions. After separation from the air-

The picture illustrates the tactical advantages offered by an inertially guided missile with an offset launching capability. After setting the coordinates of the target in the missile guidance system by either visual or radar sighting, the pilot can launch the missile from low altitude while taking advantage of ground features to avoid the target defences. From the aircraft at A, the missile is released and the motor ignites (I). At II the missile follows the guided trajectory and at III it completes the ballistic trajectory to the target B.



* «An Integrated Weapon System for VTOL Aircraft».

craft, the missile, directed by its jet vanes, snaps up into a near-vertical climb and commences its course towards the distant target. This method of launching, gives complete freedom in launch direction and in fact, the missile can be directed at a target directly ahead of the aircraft. In this case the missile will perform an over-the-shoulder manoeuvre and climb above and ahead of the aircraft prior to descending on the target. The pilot can in the meantime break away to avoid overflying the target defences and the missile burst.

Operational employment

The primary requirement in the operation of an inertially guided missile of the *Wag Tail* type is a method of target acquisition which enables the coordinates of the target position to be fed quickly and accurately into the missile guidance system. In the article already mentioned, both visual and electronic methods of fulfilling this requirement were discussed.

For visual sighting and aiming at a target which lies at some distance to the side of the aircraft track, the pilot uses a sighting device which projects obliquely from the aircraft. Assuming the target to be an airfield, to the starboard of the aircraft track, the pilot sights through the oblique sight and presses a switch when the target is correctly lined up in the sight. This passes the bearing of the target to the fire control computer. The sight is then turned through an angle of about thirty degrees and the target bearing is again transmitted to the computer when the sight is on. The distance covered between the two bearings is taken from the master inertial guidance system and the computer then solves the simple triangle to supply the target coordinates to the missile guidance sub-system.

For electronic target acquisition, side-looking radar is used. In this case, the pilot adjusts the cursors on the radar display to cover the target picture, thereby feeding the target coordinates directly to the fire control computer. A particular advantage in this method is that the aircraft is already leaving the target area when the decision to launch is made and the aircraft has the maximum safety both from ground defences and missile burst.

The method of offset launching to obtain the maximum standoff, and thus ensure aircraft survival from ground defences and safe escape from nuclear effects, also offers a number of other advantages. The pilot has ample time for target recognition and also the maximum decision time to launch the weapon. The only limitation on the decision time is the time required to fly out of missile range of the target.

No special launch manoeuvre is required because, after the target has been acquired on the radar and the coordinates passed to the fire control computer, the aircraft can continue on its flight or make evasive manoeuvres if required. The missile can, however, be launched at any time after the target coordinates have been acquired and while within missile range, and it will direct itself to the designated target position. Once the decision to launch the missile has been made, and the weapon has left the aircraft, no after-launch control is demanded of the pilot. As the missile is inertially guided it is completely immune from jamming after launch.

Although *Wag Tail* was originally designed for air-to-ground missions against tactical targets, it has been found to be adaptable to the air-to-air role also. This extension of capability is partly due to the fast reaction of the flight control system in combination with the high thrust to weight ratio of the rocket motor. The powerful control forces supplied by the three-axis jet vanes and the absence of aerodynamic control surfaces in powered flight enable the missile to perform 20 g manoeuvres.

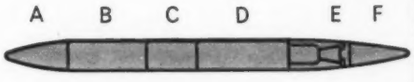
Use has been made of this flight performance capability to develop the missile as an air-to-air weapon against high-flying bombers. No extra homing equipment has been installed on the missile itself and it relies upon its high interception speed and a proximity-fused nuclear warhead to destroy the enemy aircraft.

For missile launching against airborne targets, the interceptor aircraft can use either radar or a simple optical sighting system for presetting the angles of pitch and roll axis manoeuvre into the missile guidance system. As the weapon is launched rearward, there is no requirement for radar range data after the target coordinates have been fed into the guidance system.

An exploded view of the Wag Tail missile

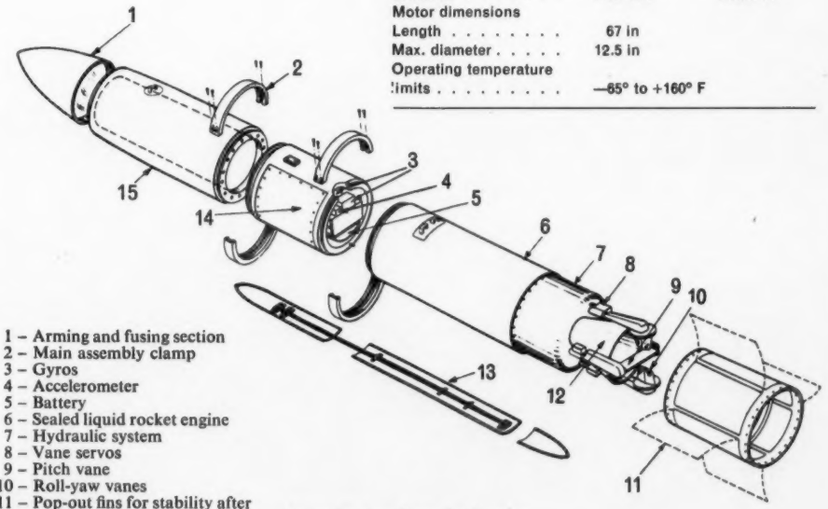
The configuration of the missile.
A. Arming and fusing
B. Warhead
C. Guidance
D. Rocket motor
E. Nozzle vanes and actuators
F. Fairing

As the missile is carried tail first on an external carrier, the rocket nozzle is enclosed by a frangible fairing which is blown clear when the motor ignites.



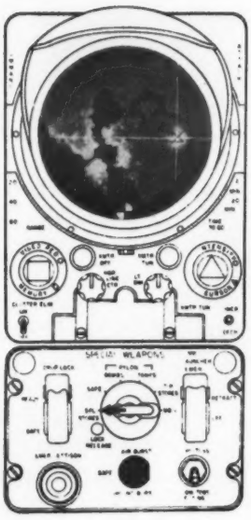
Propulsion system data

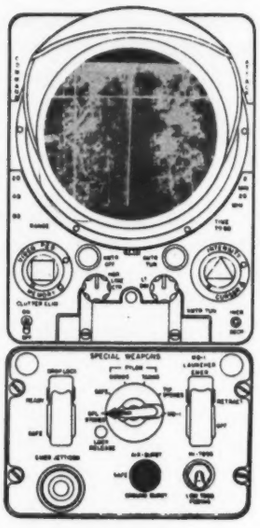
	Boost phase	Terminal phase
Thrust	10,000 lb	2,500 lb
Fuel weight	300 lb	25 lb
Specific impulse	246 sec	246 sec
Total impulse	73,000 lb/sec	6,150 lb/sec
Duration	7.38 sec	2.46 sec
Motor dimensions		
Length	67 in	
Max. diameter	12.5 in	
Operating temperature limits	—65° to +160° F	



1 – Arming and fusing section
2 – Main assembly clamp
3 – Gyros
4 – Accelerometer
5 – Battery
6 – Sealed liquid rocket engine
7 – Hydraulic system
8 – Vane servos
9 – Pitch vane
10 – Roll-yaw vanes
11 – Pop-out fins for stability after thrust cut-off
12 – Engine nozzle
13 – Cable fairing
14 – Guidance section
15 – Warhead

As can be seen from the drawing, the major subsystems such as arming and fusing, warhead, guidance and propulsion are separately packaged.





◀ The radar display as installed in the F-104G. On the left is the radar map as seen by the forward-looking radar with the horizontal and vertical cursors positioned over a landmark.

The F-104G display switched to the side-looking radar scan. The top of the radar map displays the terrain on either side of the aircraft while the picture which persists on the screen is the ground which the aircraft has flown over. Beneath the radar display is the weapon selection and arming panel. ▶

Although the use of an inertial guidance system and the absence of in-flight corrections to the intercept path may appear to offer a low degree of accuracy, studies have shown that, when used against high-altitude, supersonic targets, the kill probability of the missile is very high. This is due to the high speed of the *Wag Tail* and its launching flexibility. The interceptor aircraft is not required to fly a particular launch programme and, in consequence, the weapon can be fired immediately after the target coordinates have been acquired. The studies have demonstrated that the target has insufficient time to carry out an evasive manoeuvre which will take it out of the lethal range of the proximity-fused nuclear warhead during the flight time of the missile.

*

The history of the *Wag Tail* development by Honeywell, from the initial design studies to the existing missile, has included extensive research into component design. This has covered such problems as the aerodynamic shape of the missile, jet vane composition tests, and arming and fusing systems. The results of this test work were combined into an extensive systems test in which prototype missiles were launched from a transonic rocket sled at the USAF Air Proving Ground Center. These firings proved extremely successful and, since their conclusion, the company has been carrying out application studies. These analyses have been conducted for several mission profiles, and aircraft compatibility studies have been carried out in detail.

One of the studies has been that of the application of the *Wag Tail* to the F-104G NATO role. With only minor modification to the aircraft, the F-104G can be adapted to use the *Wag Tail* in conjunction with its existing radar in a strike role. The addition of a reconnaissance pod containing the side-looking radar (both sides) would provide complete offset launching capability and, if required, three cameras and an infra-red mapper could be incorporated in the pod to increase the reconnaissance capability.

The studies have illustrated the adaptability of the *Wag Tail* to a variety of aircraft and missions, and it is possible that the relative simplicity of the weapon, allied to its unconventional launch system, will offer a reasonable solution to the problems facing the next generation of tactical aircraft.

The Electronics of a Modern Interceptor

The Convair F-106 *Delta Dart* pictured here is one of three supersonic fighters belonging to the US Air Force, which are to be equipped with a new infra-red search and track system by Hughes Aircraft. This infra-red system is being installed in existing USA fighter-interceptors under a current modernisation programme and is intended, in particular, to increase the aircraft's efficiency at low altitudes and when faced with enemy electronic interference. The other two of the three types of aircraft in question are the Convair F-102A all-weather fighter, and the McDonnell F-101B. These jet fighters all carry the 200 black boxes of the Hughes MA-1 fire-control system, as pictured here. They use Hughes *Falcon* series rockets such as the GAR-3A (with radar homing head, shown in our picture in a vertical position) and the GAR-4A with infra-red homing head (foreground).

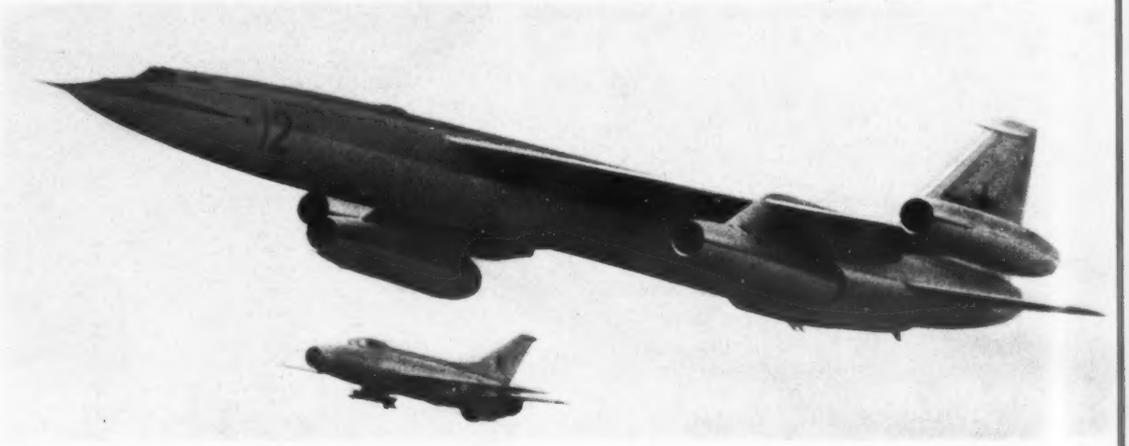
Fly-past of three supersonic fighters of a new model, developed from the Yakovlev Yak-25. According to TASS reports, some of these two-jet fighters are equipped with both air-to-air and air-to-ground missiles, and are primarily designed for ground attack missions. The radar antenna is not in the nose, as on the Yak-25, but is set in a lense-shaped pod under the fuselage, situated approximately under the pilot's cockpit. The nose is fully glassed in, and on both sides of the fuselage, forward, large-calibre gun housings are visible. The engine nacelles have a central air intake diffuser.

Soviet Show of Strength

Red Air Force Day at Tushino

This Tupolev turboprop long-range bomber (NATO designation "*Bear*") is now being assigned to heavy rocket carrying duty by the Soviets. At Tushino, it was escorted by numerous MiG-17 fighters (NATO designation "*Fresco*").

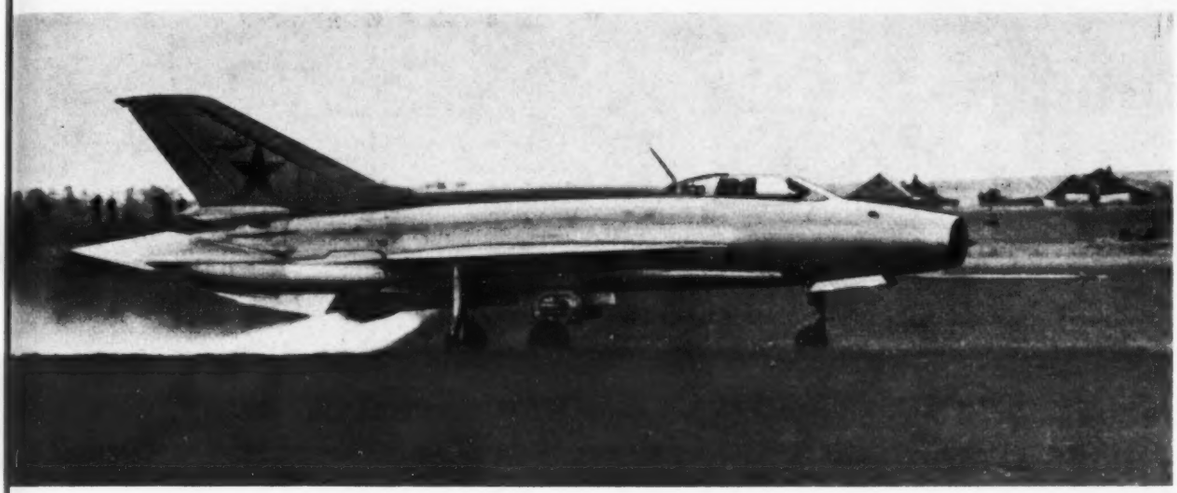
This four-jet, delta-wing supersonic bomber (NATO designation *Bounder*), whose takeoff weight is thought to be in the neighbourhood of 150 tons, was shown publicly at Tushino for the first time. The upper picture clearly shows the shape of the wings and of the tail assembly; the oval housing under the aft portion of the fuselage, which is visible in the lower pictures, is apparently for special radar antennas or navigation equipment.



The engine nacelles are ducted for secondary engine air feed. It is understood that the *Bounder* is now operational. Several speed /payload records published by the Soviets in Autumn 1959 (59,400 lb payload at a speed of 642 m.p.h. over a closed course of 625 miles) were evidently flown with this model, whose engines, according to Soviet sources, develop 28,600 lb thrust each. The escorting Sukhoi supersonic fighters are equipped with modern tactical rockets.

Left: The two-jet, all-purpose supersonic fighter shown on the preceding page. Under the fuselage, immediately behind the wing, a tub-shaped housing is visible, which is clearly for carrying a launcher for air-to-air or air-to-ground rockets.

Right: A multi-purpose aircraft with glassed-in nose, believed to be derived from the Yak-25; unlike the aircraft on the left, however, it does not appear to be designed for supersonic speeds.



A Sukhoi supersonic fighter (NATO designation *Fishbed*) takes off, assisted by two booster rocket motors located under the fuselage. A large-calibre cannon is set on either side of the fuselage, under the wing roots. The circular air intake has a central intake diffuser for the afterburner engine. Under the rear of the fuselage, two fins are mounted at right angles to each other. Both the world speed record of 2,388 km/h (1,440 m.p.h.), established in Autumn 1959 by the Soviet aircraft officially designated E.66, and the altitude record in the Summer of the same year, are believed to have been flown by this delta-wing fighter.

The well-known Mil Mi-6 large helicopter, fitted with two Soloviev turbo-engines, each rated 4,635 s.h.p., has a takeoff weight in excess of 68,000 lb and can carry 120 passengers or a 26,450 lb payload. It flew over Tushino Airport, carrying a mock-up of the Soviet space vehicle *Vostok;* the latter was equipped with additional stabilizing surfaces and a circular tail unit, presumably for stabilization of the free-trailing body. In cruising flight, auxiliary wings under the main rotor of the Mi-6 develop up to 20% of the total lift required.

This crane helicopter had its first public demonstration at Tushino. It is derived from the Mil Mi-6 and has a high 4-wheel undercarriage. Later, it lifted the pre-fabricated hut, which is visible here under the rear of the fuselage. The five-blade rotor resembles that of the Mi-6. The cockpit, too, appears to correspond to the standard model, and has a curved cabin window for a better view to the rear.

European Short-haul Air Traffic: the High-road Beckons

by Dr.-Ing. E. Skubinna, Stuttgart

As announced in the July issue of Interavia, *we present herewith an abstract of the study which was awarded the first prize in our E. E. Heiman Competition of 1961. The author is Dr. Erwin Skubinna, assisted by Helmut Brusberg and Manfred John, who are both graduate engineers.*

Dr. Skubinna, aged 48, was a student of the late Professor C. Pirath, a German transportation expert, and he received his Doctorate in Engineering in 1939 from the Darmstadt Technical Institute. During the war, he was a flight test engineer at the Luftwaffe's Lübeck-Travemünde Experimental Centre and later worked for the German Aviation Research Institute at Berlin-Adlershof; after the war he was an air traffic consultant to various Allied services in Germany, and from 1952 to 1956 he was in charge of the Traffic Division of Alweg-Forschung GmbH. Since 1957 he has been Deputy Chief of the Traffic Analysis Division of the German Research Institute for Helicopter and Vertical-Flight Techniques.

Due to space limitations, the author's manuscript has been considerably condensed; nonetheless, the main features of his treatment of the subject and his principal conclusions are set forth below.

It will be recalled that the subject of the Essay Competition was: "What could be done during the next ten years to develop short-haul air transport (over distances of up to, say, 600 miles) from the technical and economic points of view?" — Ed.

The population of Europe is about double that of the United States. Population density in Europe is, however, some three times higher than in the United States, while that in Western Europe is considerably higher. Yet the traffic statistics for 1959 of American and European IATA airlines show that passenger-miles flown per capita in the United States are six to seven times greater than in Europe. It is therefore to be expected that the next decade will witness a sharp increase in air traffic demand in Europe. Also, the steady growth of profitable transatlantic traffic should stimulate short-haul traffic and augment its customer potential. What can the airlines do to serve this demand fully?

In selecting a means of transportation, the traveller considers *speed*, which affords *travel time reduction*, along with the *fare* to be paid. The main requirement, *safety*, he takes for granted. To win permanent customers, a means of transportation must offer the convenience of a dense network of routes (coupled with rational time-tables and good connections) operated with maximum *reliability* (schedules punctually maintained and no delays). Lastly, the traveller expects all possible comfort.

Short-haul air traffic demands and possibilities

The quantitative data used in the present study for the analysis of short-haul problems refer to European conditions. They are applied to Frankfurt/Main Airport, the largest jet airport in the German Federal Republic.

With Frankfurt/Main as the centre, if a circle is drawn with a radius of 1,000 km *(Fig. 1)*, the area so enclosed undoubtedly constitutes the heart of present and future European short-haul transport, as 14 national capitals lie within its circumference, and in addition, this area has a population density nearly double that of the overall European average and six times the United States average.

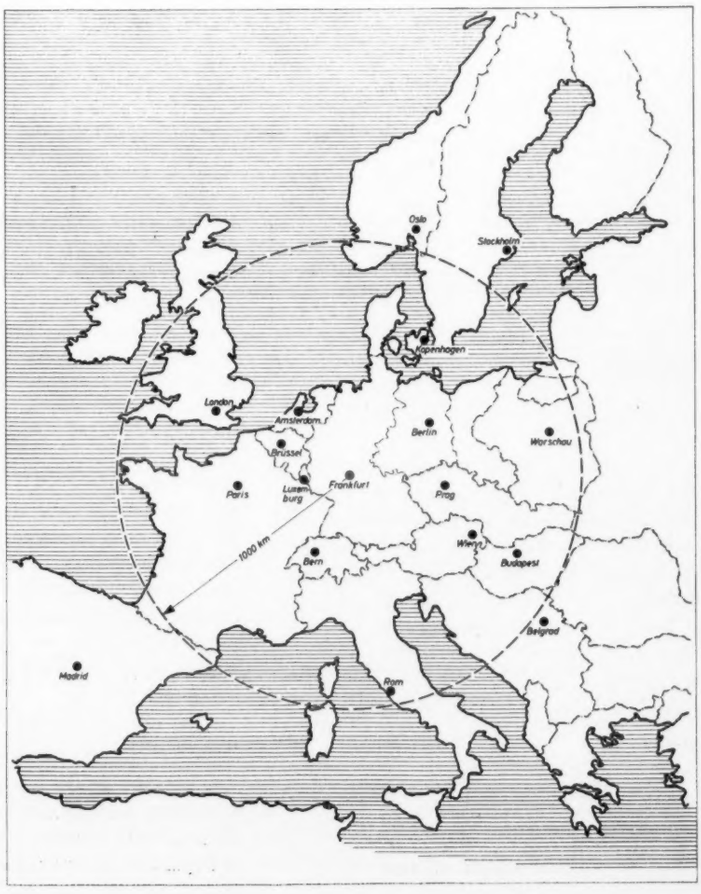


Fig. 1: The heartland of West European short-haul air traffic. While the population density of this area, with its 14 national capitals, is six times greater than the United States average, it must be remembered that extremely short flights are the rule, on routes where surface transportation is fiercely competitive.

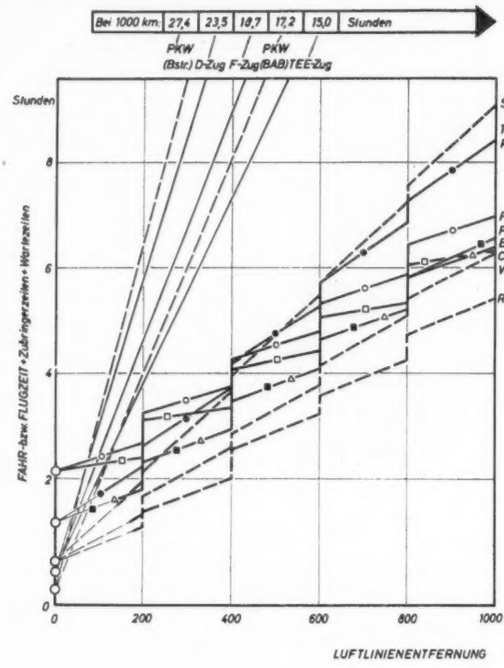


Fig. 2: Direct travel times are based on actual elapsed time in the conveyance, on the surface or in the air, and include time spent in shuttling to and from the airport, as well as waiting time during clearance of formalities. With the slowest aircraft, a 1,000 km journey including five intermediate stops can be completed in only about half the time required by the fastest means of surface transportation, the Trans-Europ Express train. In comparing the various aircraft against one other, it will be seen that for ranges up to about 350 km, the helicopter is outstanding. Moreover, a 1,000 km flight with five intermediate landings can be accomplished by the hypothetical Tilt-Wing Plane in only 69% of the time required by the fastest jet airliner in commercial service, and by the hypothetical VTOL Hover-Jet Plane in only 77% of the same time.—*Explanations*: PKW (Bstr.) = private automobile driven mainly on first-class roads. PKW (BAB) = private automobile driven mostly on superhighways. D-Zug = through train. F-Zug = Express train. TEE-Zug = Trans-Europe express. Stunden (or Std) = hours. Luftlinienentfernung = airline distance.

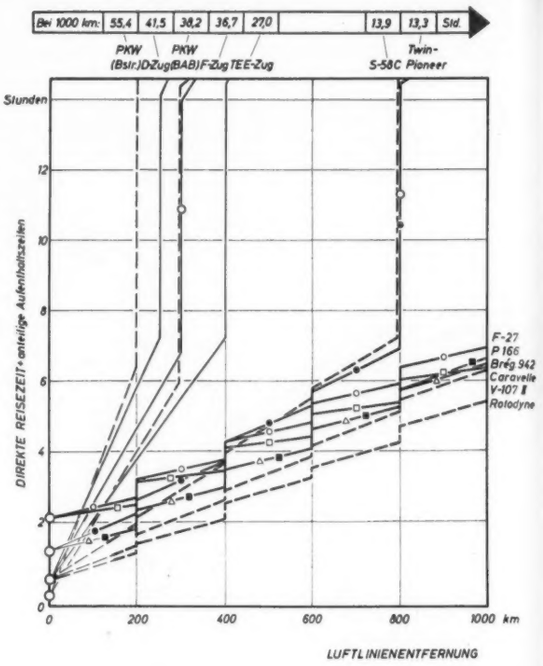


Fig. 3: Overall travel times consist of direct travel time plus a part of the layover time. It is assumed that the trip starts at 7:00 a.m. and that same-day return occurs no later than midnight. Where this is not possible, an overnight layover is taken into account by adding one-half of the total layover (after deducting three hours for transacting business) to the total travel time. The advantages of flying in the short-haul range, over surface transportation, are evident from the graph.

Travel times for more than 80 air, train, and highway routes out of Frankfurt/Main to destinations up to 1000 km away were individually investigated. Travel times were calculated on a "door-to-door" basis, which is to say that the total elapsed time taken into consideration is that taken from the time the traveller leaves his home until the time when he actually reaches the place of business at his destination.

For comparisons with surface transportation, the following types of aircraft were used:

Designation	Type *	Initial operations
Dornier Do 27	PE — fixed wing	1960
Piaggio P. 166	PE — fixed wing	1960
Scottish Twin-Pioneer	PE — fixed wing	1960
Fokker F.27 Friendship	TP — fixed wing	1960
S.A. SE.210 Caravelle	JET — fixed wing	1960
Breguet Br.942	TP — STOL (projected)	1965
Sikorsky S-58C	PE — rotary wing	1960
Boeing-Vertol 107	T — rotary wing	1962
Fairey Rotodyne	T — combination fixed/rotary	1965

* *Power plant symbols:* PE = piston engine; TP = turboprop; JET = jet engine; T = turboshaft engine.

In addition, an evaluation has been made of the commercial traffic prospects of two hypothetical VTOL fixed-wing aircraft which could, from the technical viewpoint, become operational by the end of this decade. Their characteristics follow:

Designation: *X — TWP*
TP — Tilt-wing plane
Gross weight: 44,880 lb
Payload: 27,280 lb
Cruising speed: 606 km/h

and

Designation: *X — HJP*
JET — VTOL
with lift and thrust jets
Gross weight: 61,600 lb
Payload: 8,580 lb
Cruising speed: 870 km/h

Travel time reduction possibilities

To facilitate a comparison of travel times resulting from the use of various means of air and surface transportation, *Figure 2* shows "direct travel time" (conveyance time + journey to air terminal + airport clearance procedure and waiting time) and *Figure 3* shows "overall travel time" (direct travel time + length of stay at destination).

This investigation of travelling times revealed that even in the short-haul range, the use of air transportation affords notable time savings over surface means. For overall travel time, it was noted that same-day return journeys are no longer possible when the destination is at an airline distance of over 200 to 300 km when travelling by automobile, or over 250 to 400 km when travelling by train. For the slowest of the aircraft considered, this limit is about 800 km. The journey to the airport and the waiting time for passenger clearance procedures are much more significant in short-haul air traffic than in long-haul operations. Hence every effort should be made to limit the duration of intermediate landings to an average of ten minutes, subject to variation depending on the density of local traffic. Great importance should be attached to the improvement of shuttle services between town terminals and airports. To expedite matters, the bulk of the formalities should be completed at the town terminal, with only the strict minimum left to be done at the airport. In this way, the passenger would save time, since a later departure of the shuttle service to the airport would be possible. The frequency of these services between the town terminal and the airport should be stepped up, to promote a smooth flow in process ing operations.

Economic aspects of short-haul transport

In industry and commerce today, the firmly established practice in the matter of long trips, such as from Europe to the United States, is to require travel by air in both directions whenever possible. This is done with a view to minimizing travel expenses and lost productive time. It is the author's opinion that these economic factors should also be taken into full consideration when evaluating the overall cost of short-haul transportation, and in selecting the most economic means of transport, in view of the substantial time savings effected by air travel in comparison with surface means, even in ranges below 1,000 km.

If overall travelling costs be compared for air and surface transportation (direct costs plus meals plus lost productive time due to absence), it will be seen that based on current fare structures, automobile travel is the highest in cost, while air travel falls in the lowest cost bracket; these relationships are shown in *Figure 5*. Under the same assumptions, the helicopter proves to be the most economical way to travel distances in the range from 50 to about 300 km.

The travel cost relationships shown in *Figures 4* and *5* do not yield any indication as to the economic feasibility of short-haul air traffic, as they are based in part on a fare structure which does not always reflect true operating costs. An attempt has therefore been made to evaluate these costs, based on a uniform set of assumptions. A passenger load factor of 50% was used throughout, and in determining total costs, all direct and indirect operating costs have been included so that the fares—direct travel costs—thus calculated may be considered to be realistic *(Fig. 6)*.

If one now compares overall travel costs again, based on these realistic fare estimates, for air and surface transport, the relationships shown in *Figure 7* are obtained; the overlapping cost ranges for automobile and rail transportation will be noted. Beyond about 400 to 450 km, the cost curves for the *Friendship* and the Breguet Br.942 lie increasingly below the lower limit for railway costs. The cost curve for the Boeing-Vertol 107 II lies well above the main body of overlapping curves. Except for the S-58, the travel cost curves

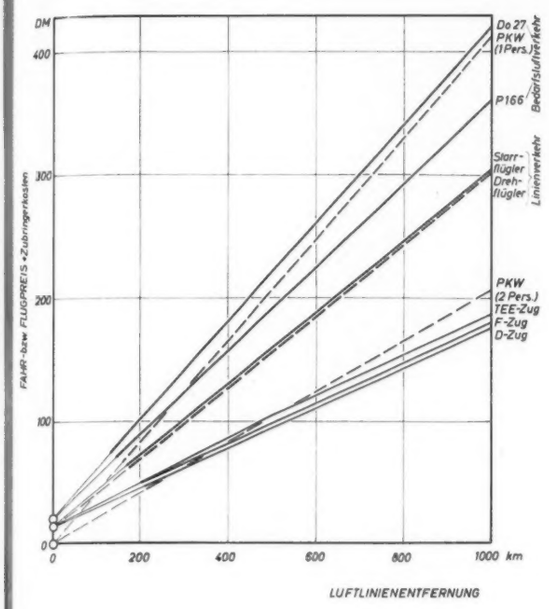


Fig. 4: Direct travel costs include the air fare or train fare and the cost of the airport shuttle service. They are based on *actual current fares*. The author's values, expressed in DM (Deutsche Marks), have been retained on the graph, to avoid possible misrepresentations. The reader can make an approximate conversion using a rate of 100 DM = $ 25. *Explanations:* Nahluftverkehr = short-haul. Drehflügler = helicopter. Starrflügler = fixed wing aircraft. Linienverkehr = regular service, Bedarfsluftverkehr = charter. For other terms, see *Fig. 2*.

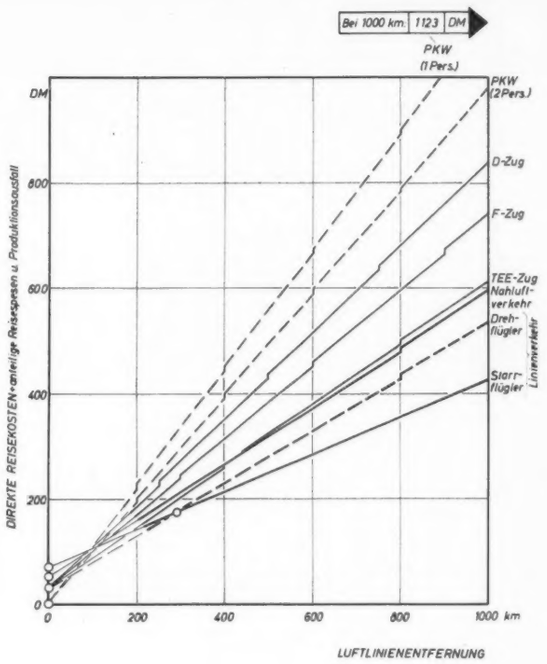


Fig. 5: In a comparison of *overall travel costs* (direct travel costs plus meals plus lost productive time due to absence from the job) based on *current fares*, the private automobile cost range is the highest, while the fixed-wing aircraft range in costs is the lowest. (See *Fig. 4* for remarks concerning "DM" currency unit).

for all the other aircraft—including the *Rotodyne*—start to overlap those for other forms of transportation after about 300 km, so that total flying costs are no greater than those of travelling by local or express train, and fall into the lower third of the private automobile cost range shown by the graph.

The cost/speed ratio

As stated earlier in this study, the passenger is primarily interested in speedy travel at reasonable cost. It therefore appears desirable to devise a suitable, albeit theoretical, economic yardstick to be used in comparing the various means of transportation, which would take into account these two very different aspects, namely, travel time and total cost.

To meet this need, the writer proposes the so-called "cost/speed ratio," which to his knowledge has not thus far been applied to transportation economics. The "cost/speed ratio" denotes the cost of travel per 1 km/h of speed.

Figures 8 and *9* show cost/speed ratios based on present fares for 300 and 900 km journeys (airline distances). They clearly show that short-haul air transportation sells speed at lower cost than surface means.

If one compares the overall cost/speed ratios of air and ground transportation for distances of 100, 300, 500, and 900 kilometers, it will be found that this ratio is significantly lower for all aircraft than for the fastest means of surface transportation. For the four distances mentioned, the ratios drop to the following values relative to surface means of transportation:

Boeing-Vertol X 107 II
from 88 % down to 22 %

Fairey Rotodyne
from 70 % down to 17 %

hypothetical X-HJP JET-VTOL hover plane
from 76 % down to 13 %

hypothetical X-TWP TP tilt-wing plane
from 40 % down to 7 %

In assessing the *overall economic feasibility* of a transportation facility, the potential profit return on the vehicle alone is not the only factor to be considered; the cost of the ground installations required for its operation must also be weighed.

In short-haul air transport, these considerations are particularly relevant with respect to helicopters and the VTOL aircraft above (e.g., the X-TWP and X-HJP). Although these aircraft

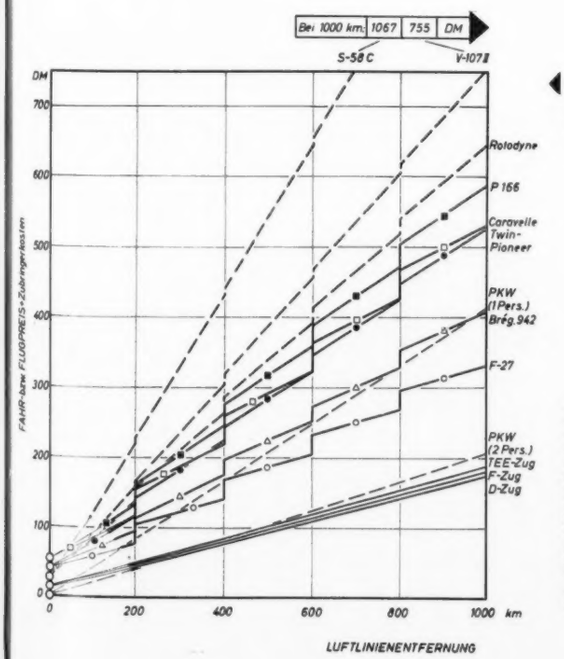


Fig. 6: Direct travel costs air or train fare plus shuttle service to airport), based on estimated *total operating costs*. (See *Fig 4* for remarks concerning "DM" currency unit and *Figs. 4* and *2* for explanation of terms.

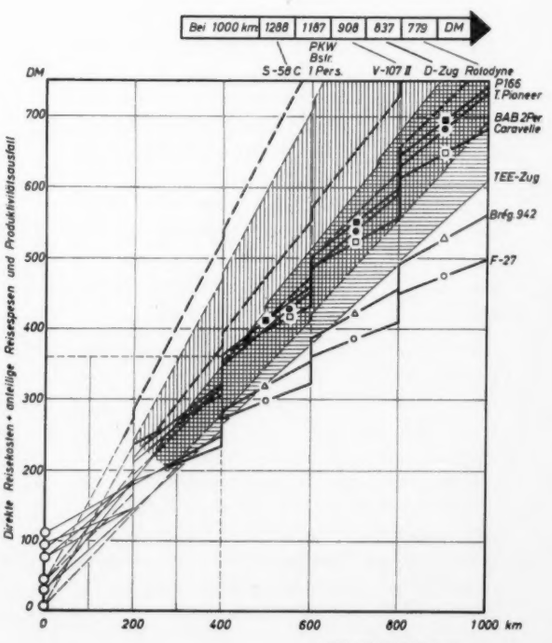


Fig. 7: Overall travel costs (consisting of direct travel costs plus meals plus lost productive time) based on estimated *total operating costs*. Comparison of overall travel costs for air and surface transportation reveals that the cost ranges for private automobiles and railways partly overlap. The cost lines for the Breguet Br. 942 and the *Friendship* lie below the lower limit of railway costs beyond 400 to 450 kilometers. The cost line for the Boeing-Vertol 107 II rises steeply over the upper limit of the overlapping automobile and railway cost range. With the exception of the S-58, the cost curves of all the other aircraft lie in this overlapping range.

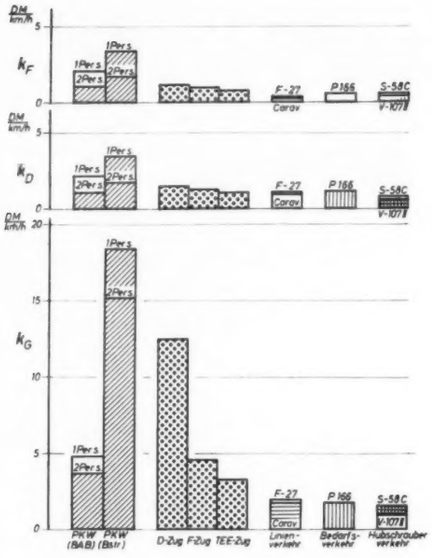


Fig. 8: Cost/speed ratios for various means of transportation in DM per km/h for 300 km distances. The cost/speed ratio denotes travel costs per 1 km/h of speed. Abbreviations: kF (upper row): *pure cost/speed ratio* = air or train fare divided by the net air or train time (based on airline distances). kD (middle row): *direct cost/speed ratio* = direct travel costs divided by direct travel speed (based on airline distances). kG (lower row): *overall cost/speed ratio* = overall travel costs divided by overall travel speed (based on airline distance). *Explanations:* Hubschrauberverkehr = helicopter service. For other terms, see *Figs. 4* and *2*.

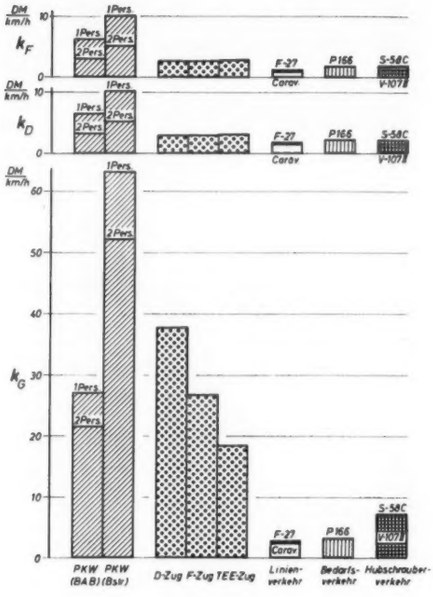


Fig. 9: Cost/speed ratios for various means of transportation in DM per km/h for 900 km distances (see comments for *Fig. 8*).

are high-priced and relatively costly to operate, their ground support requirements are of such limited scope that airfield costs are much lower, and on balance, their economic feasibility is enhanced.

Frequency and timing of flight services

European air transportation today is primarily a feeder service for the large intercontinental airports. This unsatisfactory state of affairs in short-haul transportation could be corrected by evolving a more rational flight service pattern with coordinated timing and improved frequencies. In order to optimize this type of air transportation service, it would be advisable to do some market research and conduct origin-destination surveys, so as to keep constantly abreast of market trends and requirements. It would seem reasonable to expect about 3 or 4 inbound and outbound flights daily as a general rule for average routes, and up to 6 or 7 such flights daily on heavily-travelled main routes. Planning flight services of this density requires extraordinarily complicated computations since transfer connections at junction points must be facilitated and stop-over waits held to a minimum. On the basis of a traffic analysis derived from a market survey, the optimum pattern of flight services offered to the public could be worked out with the aid of an electronic computer.

Reliability

It is particularly important for short-haul transportation to provide reliability, i.e., regularly on-time services, since the time factor in this field is far more vital than in long-haul operations. It is the rare passenger who will forgive and forget delays, cancellations, and missed connections. The degree of punctuality and regularity maintained by the railways is the goal for which European short-haul air service should strive; it can be attained. This will be difficult of accomplishment in winter, as experience has shown that delays and detours are a daily occurrence in Europe due to unfavorable weather conditions during that season. These hindrances, which so inhibit the further expansion of air traffic, will disappear only when risk-free, automatic instrument landing systems are available to civil aviation.

According to some American experts, fully automatic instrument landings should be routine operational procedure within 4 or 5 years, and in some 10 years no manual control equipment at all will be required in the aircraft. That this optimistic prophecy should come to pass is not altogether unlikely, in view of the several thousand landings which have already been successfully carried out with the American BELL and British BLEU landing systems. However, in their present state of development, these procedures do not as yet guarantee absolutely risk-free automatic instrument landings.

The full development of short-haul air transportation is also largely dependent on the solution of various other air safety problems, which cannot be examined in detail in this study. Until a fully satisfactory solution to air safety problems is developed, short-haul air services should do their best to meet their customers' demand for reliability. For example, when flights are detoured or cancelled, or when the passenger misses his connection, he should be enabled to continue his journey by whatever means he deems best and most convenient.

Comfort

In short-haul traffic, a somewhat Spartan degree of comfort is acceptable to the passenger. It has been suggested that expenses could be pared by reducing or eliminating altogether the customary in-flight steward services. By doing away entirely with refreshments in the air, the number of hostesses or stewards could be reduced.

The author is however of the opinion that for flights lasting more than one hour, the traveller should be offered the possibility of purchasing drinks, food, and cigarettes on board. For example, aircraft assigned to short runs could be equipped with removable automatic dispensers for refreshments, made of light metal.

Conclusions

- The development of short-haul air traffic in the coming years hinges on airline performance, as judged by the discriminating travelling public, which demands speed, at no premium in price, as well as utmost safety, reliability, and comfort. This, in turn, presupposes the prosecution of a purposeful air facility program sustained financially by public bodies and authorities, aimed at strengthening European air services and providing the optimum number of airports, and which would also promote a genuine expansion in medium- and long-haul air traffic.
- A further essential requirement, if short-haul air traffic is to prosper, is the development of airborne and ground-based equipment, as well as air safety procedures, which will guarantee regular all-weather flight operations.
- Cost-wise, short-haul air services are competitive with surface transportation when indirect costs and time savings are taken into account. It would appear, however, that current intra-European air fares must be lowered down to the American level.
- Suitable conventional aircraft are available for various ranges of short-haul operations. Furthermore, it is likely that within the next few years, new types of aircraft will be developed, such as turboshaft helicopters and STOL designs, with true all-weather capabilities. Among the many VTOL projects, the tilt-wing design seems most promising for short-haul applications, and will probably be the first to progress to the operational stage.

The Super-Broussard

A Sturdy Passenger Aircraft for Short-haul Routes

The history of the *Super-Broussard* starts in the year 1954, when the Société des Avions Max Holste decided to develop a ten-passenger twin-engined feeder aircraft. Before detailed work on design began, however, enquiries were made of a number of airlines, both in France and abroad, in order to ascertain whether sufficient demand for an aircraft of this type existed. In the course of this virtually world-wide market research, during which a number of Max Holste engineers were sent abroad to discuss all relevant questions personally with airline planning chiefs, it soon became clear that the seating capacity would be too low if fixed at the figure of ten. The airlines unanimously agreed that what they needed was a short-haul aircraft with about twenty seats and operating costs as low as possible, able to link populated areas, where potential traffic did not warrant the expense of a large airport, to the international network.

This particularly applies to the fast developing countries, where the aircraft is often the only regular means of transport. On the other hand, in order to operate regular scheduled flights in remote areas under severe climatic conditions, an aircraft should be designed to fulfil certain conditions, namely:

- sturdy structure;
- suitability for landing and takeoff from auxiliary-type landing strips;
- a sufficiently attractive cruising speed;
- a moderate initial cost, in order to allow profitable operation even over the shortest routes.

The one factor omitted from this list is comfort. It would have been unsuitable to provide deliberately "cheap" aircraft with a sophisticated cabin interior, since flight time on most stages would in any case be short. However, by introducing too crude equipment, a carrier runs the risk of losing his passengers to competition, which may provide greater comfort, and it is a delicate matter to find the right compromise in this matter.

Since, however, the French General Staff was interested in a multi-purpose transport of about the same size, there was an obvious possibility of designing the military and civil versions alongside one another. Design work proper began in 1957, the project in the meantime having been named the *Super-Broussard,* and two years later, on May 20th, 1959, the MH.250 prototype took off on its maiden flight. Although it had already been decided to fit the production *Super-Broussard* with turboprop engines in the 1,000 h.p. power class—choice lay between the Turboméca *Bastan,* the Armstrong-Siddeley P.182, and the Lycoming T 53—to avoid delays in commencing flight testing, the MH.250 was first equipped with Pratt & Whitney R-1340 600 h.p. piston engines. On the basis of the results, which fully confirmed the calculated performance data, the Rheims facility started building the second prototype, the MH.260, this time to series-production specifications and, on October 5th of the same year, Max Holste and Nord-Aviation signed an agreement under which both companies were to participate closely in the further development and production of the *Super-Broussard.* In April, 1960, before the MH.260 had even made its maiden flight, the French Ministry of Transport placed a contract with Max Holste covering the development of a version incorporating a pressurized cabin, as well as the work preparatory to series production. For this purpose, an allocation of NF 23 million was earmarked in the civil aviation budget. Among those who have recently shown interest in the *Super-Broussard* and filed buying options are Australian, Dutch, and Moroccan airlines. The MH.260, fitted with two *Bastan* engines, each with a takeoff rating of 1,000 e.h.p., began its test flights on April 29th, 1960.

Towards the end of last year, Nord-Aviation announced that, under their agreement with Max Holste they will be taking over the series production and sales of the *Super-Broussard.* Nord-Aviation has played a leading part in the development of the MH.262 pressurized cabin version of the *Super-Broussard,* first flight of which is sched-

Prototype of the Max Holste *Super-Broussard,* a short-haul transport aircraft for 20—23 passengers, powered by two Turboméca *Bastan IV* turbo-prop engines, each 1,000 e.h.p. takeoff rating. The *Super-Broussard* is being produced by Nord-Aviation in two versions, the MH.260 without pressurized cabin, and the MH.262 with pressurized cabin.

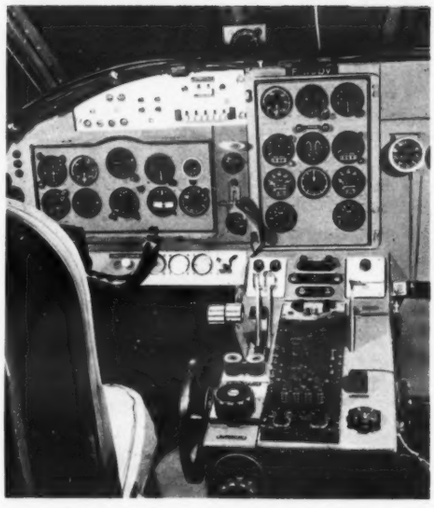
uled for the summer of 1962. On April 5th, 1961, the French Secretariat for Civil Aviation selected the *Super-Broussard* as the standard type for short-haul operations, following a government-sponsored competition which had also been entered by Potez (the Potez 840) and by Sud-Aviation jointly with Marcel Dassault (the *Communauté AI*). Further Government financial support for this aircraft is accordingly assured, NF 15 million being available for this purpose during the current financial year.

Technical Description

Apart from the fuselage and the differences arising from it, both the MH.260 and the MH.262 versions have the same structural design. By building the airframe of numerous removable components, repairs can easily be carried out without the necessity for grounding the aircraft for long periods. Both versions meet the French Air 2051 official construction specifications, which are virtually a transcription of the American CAR 4b and the US SR-422A regulations for turbine-powered aircraft.

As regards the airframe, the "fail-safe" principle has been applied throughout. The high wing consists of a centre section, carrying the engine nacelles, and two outer sections. Bending and torsion stresses are taken by a twin-spar box, which also serves as a fuel tank. The wing leading edge is sub-divided into eight sections, which tends to facilitate not only the replacement of a damaged component, but also the inspection of the spar. The double slotted flaps are also of all-metal construction, while the single-slotted ailerons are fabric-covered.

The tail unit is conventional throughout: the horizontal stabilizer is built in a similar way to the wing, but not divided into sections; the fin



View of the cockpit of the MH.260 prototype. In the production version, the instrument panel will have a slightly different layout.

skin is stressed together with the spars and ribs. The rudder is also fabric-covered. All control surfaces are actuated by cables, in some cases four-ply.

As shown by the exploded drawing below, the fuselage is built in three main assemblies, namely a fore section with cockpit and nose landing gear, a centre section with passenger cabin and auxiliary compartments, and a rear section with baggagecompartment.TheMH.260accommodates up to 23 passengers. In the standard version, 20 seats are planned (these are tourist class seats as installed in the *Caravelle*), whilst the pressurized MH.262 will have seating capacity for up to 26 passengers. The *Super-Broussard* can be equipped for all-freight operations or for mixed payloads (passengers and freight). Permissible loading for the cabin floor is 82 lb/sq.ft. The following dimensions for windows and doors apply only to the MH.260: both fuselage sides have six circular windows (diameter about 21 in) with panes made of two plexiglas layers (¼ in and $^1/_6$ in), the main door (3.77 ft wide × 3.86 ft high) is aft on the port side of the fuselage; another door (2.64 × 5.6 ft) forward on the port side of the fuselage is available for the crew. Two of the windows are designed as emergency exits; in the case of ditching, passengers can get out of the cabin through a hatch in the roof.

The air-conditioning plant can maintain any temperature between 15°C and 22°C inside the cabin at external temperatures down to — 35°C; moreover, when the aircraft is on the ground

The MH.260 normal seating arrangement for 20 passengers. In the background can be seen the door of the washroom and a space for hanging coats.

even in the glaring sun, the air-conditioning plant prevents the inside temperature from rising above the outside temperature, provided that the latter does not exceed 40°C.

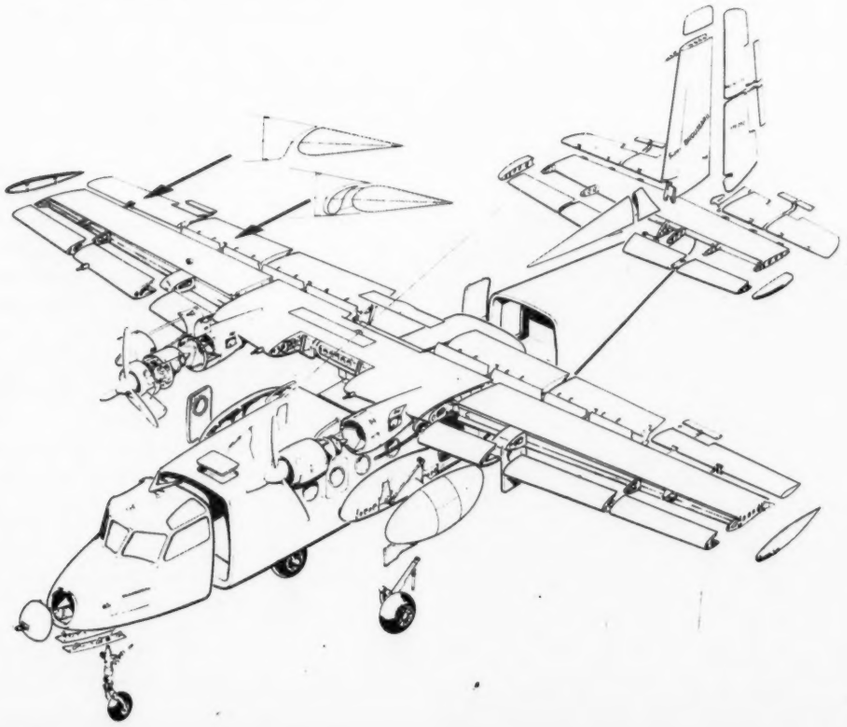
The main characteristic of the landing gear is the simplicity of its design. The two main units are linked together by a torsion rod and retract into two fairings overlapping on both sides of the underpart of the fuselage; tyre pressure is 53.3 p.s.i. The nose wheel leg can turn through 360°; its tyre pressure is 50 p.s.i.

The large cockpit may be equipped for either one or two pilots, as desired. In the latter case, provision is made for dual flight instruments; the console between the pilots' seats carries all controls for flaps, rudder tab, propeller pitch, radio installation, automatic pilot, starter, and fire extinguisher. Switches for the air-conditioning plant, and for the electric, de-icing, and lighting systems are on the overhead panel.

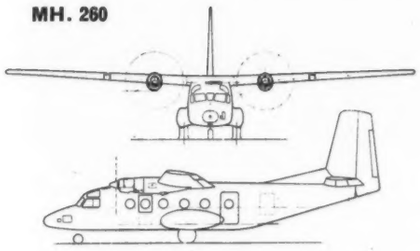
As standard equipment for R/T communication and navigation, Nord-Aviation suggests the following combination as mandatory: dual VHF receiver and transmitter, one glide path receiver, one VOR, one marker receiver and one ADF (all by Collins), one additional compass (Bezu), one automatic pilot (SFENA), one radio-altimeter (CSF), and one intercommunication system (TEAM). The purchaser, of course, remains free to choose the equipment he prefers.

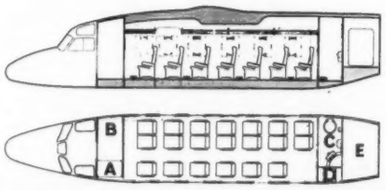
The landing gear, the brakes, the flaps and the rudder lock are operated hydraulically, operating

Sub-assemblies of the non-pressurized MH.260



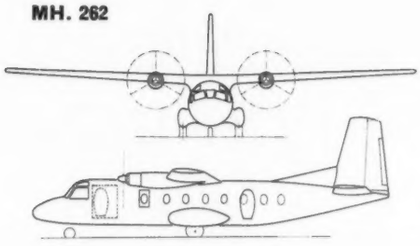
MH. 260

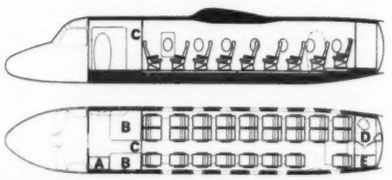




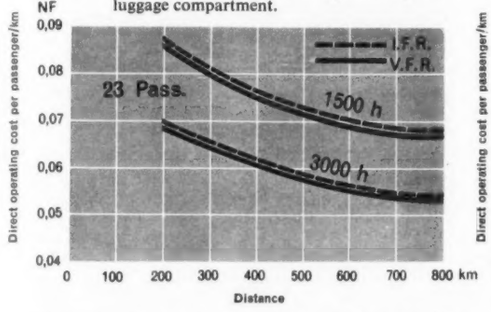
Standard seating lay-out for 20 passengers. Spacing between seat rows 34.3 in, width of gangway between seat backs 19.9 in. A – compartment for electrical equipment; B – provision for a galley; C – toilet and washroom; D – clothes compartment; E – luggage compartment.

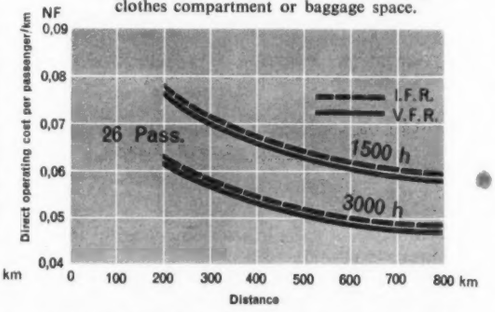
MH. 262





Seating lay-out for 26 passengers. Spacing between seat rows 33.7 in, width of gangway between seat backs 20 in. A – compartment for electrical equipment; B – Baggage compartment; C – removable partition; D – toilet and washroom; E – clothes compartment or baggage space.





Direct operating cost per passenger/km vs distance, calculated by the SBAC method. Assumptions: aircraft depreciated down to 10% of purchase price over 8 years; interest on capital outlay 4% p.a.; insurance 5% p.a. Fuel reserves for 45 minute hold under V.F.R. conditions and for 45 minute hold plus 231-mile detour under I.F.R. conditions.

Technical Data	MH.260	MH.262
Span	70.55 ft	
Length	59.18 ft	62.07 ft
Height	23.33 ft	22.97 ft
Wing area	592 sq.ft.	
Aspect ratio	8.71	
Dihedral	3°	
Angle of incidence	3°	
Landing gear	Steerable nose wheel assembly by E.R.A.M.	
Wheel track	9.88 ft	10.27 ft
Power plant	Two Turboméca **Bastan IV** turboprop engines, each of 1,000 e.h.p. takeoff rating.	
Propellers	Ratier-Figeac FH 86 variable pitch propellers (diameter 9.51 ft).	
Empty weight	11,453 lb	11,814 lb
Empty weight (equipped)	11,915 lb	12,870 lb
Max. take-off weight	21,560 lb	21,670 lb
Max. landing weight	20,680 lb	
Max. payload		
Passenger version	6,292 lb	4,967 lb
Freight version	7,435 lb	7,382 lb
Economic cruising speed	247 m.p.h.	250 m.p.h.
Maximum rate of climb	1900 f.p.m.	
Service ceiling	32,175 ft	32,340 ft
Max. range	994 miles	1,111 miles
Takeoff run[1]	approx. 2,150 ft	
Takeoff run with one engine[1]	approx. 3,950 ft	
Acceleration and stop distance[1]	approx. 4,300 ft	

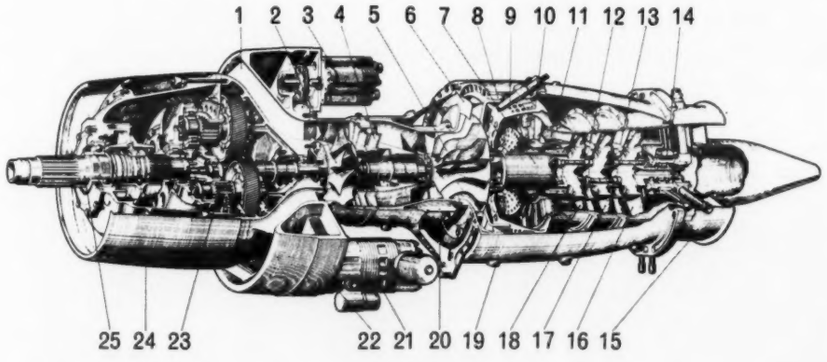
[1] at maximum takeoff weight.

pressure being 3,350 p.s.i. Two generators—6 kW design output, 9 kW maximum output—supply 28 V direct current; alternating current (115 V, 400 Mc/s) required for the gyro instruments, artificial horizon, radio compass, and VOR is supplied through a converter.

For details of the performance data and operating costs, the reader is referred to the accompanying box.

In the *Super-Broussard*, with its cruising speed of 250 m.p.h. and a continuous rating of twice 800 s.h.p., which seem thoroughly reasonable considering the spacious cabin and accordingly large cross-section of the fuselage, and its takeoff and landing characteristics, which should be adequate for all demands, Max Holste seems to have found a happy compromise between the conflicting wishes of a number of airlines. And the calculated operating costs are undoubtedly attractive.

The fact that hundreds of DC-3s, often more than 25 years old, are still in regular service to-day not only testifies to the indestructibility of this model, but is also striking proof that an ideal successor has not yet been found. And it never will be. The catchword "successor to the DC-3" has already become a commonplace, and one that is all too often abused by aircraft constructors. Nord-Aviation and Max Holste point out that today the operational range of the DC-3 can no longer be covered by one model, since no such aircraft could on the one hand conform with the great increase in standards of comfort and performance over the last decade, and, on the other, show operating costs the same as, or lower than, the veteran DC-3s which have been amortized many times over. Two models, not one, would in fact be necessary to "take over" from the DC-3. These are a large aircraft for about 40—50 passengers, incorporating all the features of a sophisticated transport—a market for which some constructors are already struggling—and, to complement it, a robust transport in the 10-ton class, which can be profitably employed in the short-haul and very-short-haul trade, and needs no more than modest ground installations: in a word, the *Super-Broussard*. And there is every likelihood that this aircraft will prove the two French constructors right in their philosophy. ←→



Sectional drawing of Turboméca Bastan IV turbo-prop engine

1 – Air intake
2 – Compressor axial stage
3 – Inverted flight oil pump
4 – Guide blades
5 – Compressor radial stage
6 – Radial guide vanes
7 – Hollow shaft
8 – Axial guide blades
9 – Ignition unit
10 – Annular-combustion chamber
11 – First turbine guide-blade ring
12 – Second turbine guide-blade ring
13 – Third turbine guide-blade ring
14 – Rear bearing
15 – Exhaust diffusor
16 – Third turbine rotor
17 – Second turbine rotor
18 – First turbine rotor
19 – Turbine casing
20 – Compressor casing
21 – Normal flight attitude oil pump
22 – Accessory flange
23 – Reduction gear
24 – Gear box hood
25 – Propeller shaft

Four of the five altitude research rockets developed by Sud-Aviation in collaboration with the Centre National d'Etudes des Télécommunications (CNET), which was responsible for design of the rocket head and of the measurement equipment. All these rockets have a common final stage, namely the *Bélier* (pictured here), which is thus, so to speak, the father of the whole family of sounding rockets which Sud-Aviation is to produce. The *Bélier*, and the next larger *Centaure*, are already in production and first launch trials of these two probes have meanwhile taken place.

The Bélier Rocket Family

French Altitude Research Rockets—Joint Developments of the Centre National d'Etudes et des Télécommunications and Sud-Aviation

"Colloquium on Altitude Research Rockets" was the title of a Conference, for which scientists from three countries—France, Great Britain, and Italy—assembled in Paris on June 23rd. The organiser and host was the Société Française d'Astronautique; the British Interplanetary Society and the Associazione Italiana Razzi were represented.

The questions for discussion related to the production and employment of altitude research rockets and also covered problems to which the quick and rational evaluation of the measurements yielded by such rockets gives rise. Apart from this, the very fact of a meeting of rocket scientists is significant; Great Britain, France, and Italy are highly interested in getting a European space research programme under way covering, if at all possible, the development of European carrier rockets, but in any case satellites of European conception. It is to be assumed that, once a project of this nature is realized, the German Federal Republic would not stand aside.

However one may judge the meeting in Paris, it is certain that the step from the multi-stage altitude research rocket to the carrier vehicle for small satellites poses no insuperable difficulties.

Some of the French firms who are extremely active in the space field were on this occasion prepared—at last—to give some clues about the work so far done in France.

In this connection, the concern we have mainly in mind is Sud-Aviation, details of whose family of new space probes were made available for the first time. In these rockets, which were built in collaboration with the Centre National d'Etudes des Télécommunications (CNET), the main elements used in construction, with the exception of the components of certain equipment, are standardized.

Common to all members of Sud-Aviation's families of sounding rockets is the *Bélier*, a single-stage rocket with a standardized CNET head, in which all the measuring and recording equipment is accommodated. The rocket is powered by a solid propellant rocket motor of unnamed construction and the probe is intended for measurement at altitudes of up to 50 miles. The *Bélier* does not carry remote control equipment of any kind. The sounding rocket is roll-stabilized i.e. by slight displacement of the fins at the rear it is put into slow rotating motion about its longitudinal axis.

However, in order to achieve sufficient longitudinal stability immediately after launch and, accordingly, at relatively low flight speeds, two auxiliary powder rockets of short combustion period, located on opposed fins, are ignited the moment the rocket leaves ground. They give the *Bélier* additional roll moment.

The probe is, moreover, fitted with a device for self-destruction, in case necessary. The arrangement of all antennas on the stabilization fins is somewhat unusual—these are partly on the fin trailing edge and partly in streamlined fairings at the fin tips.

The Centaure

Further development of the *Bélier* led to the creation of the two-stage *Centaure*, which uses a slightly lengthened *Bélier* as its final stage, and has a booster of relatively short-combustion period as first stage. The four stabilization surfaces on the stern of the first stage carry no antennas; as in the case of the *Bélier*, they are arranged on the control surfaces of the second stage. Small auxiliary rockets on the two opposed control surfaces of the first stage generate sufficient roll to ensure stabilization of the rocket immediately after launch.

The separation of the first and second stages is carried out by an annular hollow charge of rela-

Sud-Aviation Sounding Rockets

	Bélier	Centaure	Dragon	Pégase	Eridan
Total length	157.9″ (4011.5 mm)	237.1″ (6022 mm)	279.2″ (7098 mm)	407.2″ (10343 mm)	297.1″ or 328.6″ (7547 or 8347 mm)
length of first stage	—	—	119.1″ (3024.5 mm)	122.7″ (3117 mm)	122.7″ (3117 mm)
length of second stage	—	—	160.4″ (4073.5 mm)	122.3″ (3106 mm)	174.4″ or 205.9″ (4430 or 5230 mm)
length of third stage	—	—	—	162.2″ (4119.5 mm)	—
Diameter – first stage	12.0″ (305 mm)	11.0″ (279.5 mm)	21.9″ (556 mm)	22.0″ (558 mm)	22.0″ (558 mm)
– second stage	—	12.0″ (305 mm)	12.0″ (305 mm)	21.9″ (556 mm)	21.9″ (556 mm)
– third stage	—	—	—	12.0″ (305 mm)	—
Span of stabilizers – first stage	30.8″ (782 mm)	28.5″ (725 mm)	48.2″ (1225 mm)	61.1″ (1553 mm)	61.1″ (1553 mm)
– second stage	—	30.8″ (782 mm)	30.8″ (782 mm)	48.2″ (1225 mm)	48.2″ (1225 mm)
– third stage	—	—	—	30.8″ (782 mm)	—
Total launching weight	694 lb (315 kg)	1,029 lb (467 kg)	2,550 lb (1157 kg)	4,512 lb (2047 kg)	4,422 lb (2006 kg)
– first stage	—	335 lb (152 kg)	1,843 lb (836 kg)	1,962 lb (890 kg)	1,874 lb (850 kg)
– second stage	—	—	—	2,480 lb (1135 kg)	1,843 lb (836 kg)
– third stage	—	—	—		—
Payload	70 lb (32 kg)	70 lb (32 kg)	70 lb (32 kg)	70 lb (32 kg)	130—705 lb (60—320 kg)
Maximum altitude	50 miles (80 km)	90 miles (140 km)	250 miles (400 km)	590—630 m (950—1000 km)	approx. 105—250 miles (170—400 km)
Burning time – first stage	21 sec	4.5 sec	19 sec	19 sec	19 sec
– second stage	—	21 sec	21 sec	19 sec	19 sec
– third stage	—	—	—	21 sec	—
Maximum speed (at altitude)	4,495 fps (7.5 mi) (1370 m/s—12 km)	5,480 fps (12 mi) (1670 k/s—20 km)	5,410 fps (26 mi) (1650 m/s—42 km)	12,800 fps (50 mi) (3900 m/s—80 km)	approx. 5,410 fps—8,200 fps (1650—2500 m/s)
Max. longitudinal acceleration	13 g	15 g	15 g	17 g	—
Time to max. altitude	2 min 10 sec	3 min 12 sec	5 min	9 min 10 sec	—
Time to drop back to earth	4 min 20 sec	6 min 15 sec	10 min	17 min 40 sec	—

tively small explosive effect; a timing mechanism, which automatically starts working when the rocket leaves the launch ramp, sets off the ignition.

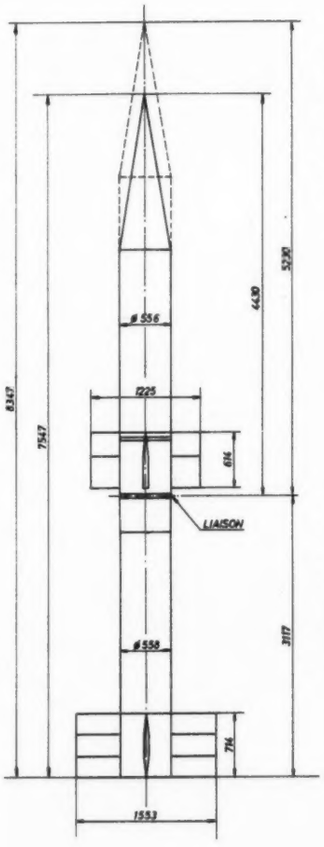
Data and performance figures in respect of the *Centaure* are included in our table. Production of the *Centaure*—like that of the *Bélier*—has started on a limited scale (10 *Centaures* to be built at present); the first launching trial of both the *Bélier* and the *Centaure* have taken place.

The Dragon

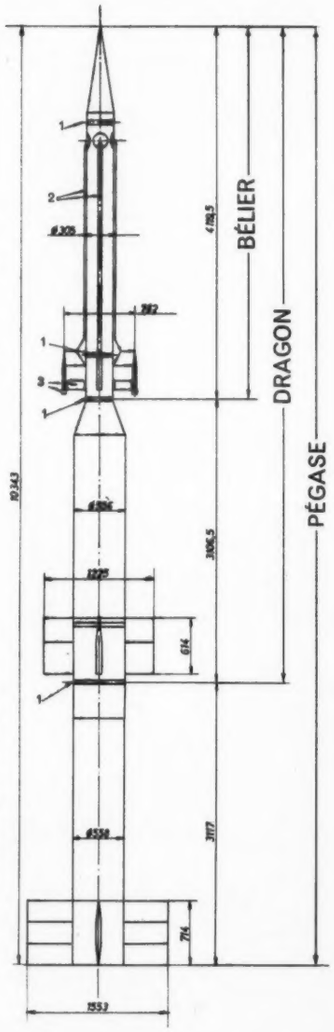
The member of the family designed for research into the outer atmosphere (altitude of up to 250 miles) is the *Dragon*, another of the fruits of collaboration between CNET and Sud-Aviation. Research work on this sounding rocket has now been completed, and individual components of the rocket motors are being subjected to first bench tests. The *Dragon* uses a *Bélier* as its final stage, in the same way as the *Centaure*. In contrast to the original version of the *Bélier*, however, the *Bélier* final stage in the *Dragon* has a stiffened airframe; furthermore, the carrier ring at the back of the final stage with the stabilization surfaces will, for technical reasons connected with assembly, be longer. As booster/first stage of the *Dragon*, a *Stromboli* solid propellant motor is the one expected to be used, but as yet no details concerning it are available. For the rest, no fundamental differences exist between the *Centaure* and the *Dragon*. The four stabilization surfaces of the *Dragon's* booster each carry one double auxiliary rocket, in order to give the probe the required roll immediately after takeoff.

The separation of first and second stage is done in the same way as in the *Centaure*. The *Bélier* used as the second stage has its antenna arranged on the stabilization surfaces in the manner already mentioned. Two further auxiliary rockets are located on these surfaces for maintaining rotational movement about the probes longitudinal axis.

As distinct from the *Bélier* and *Centaure* probes, which are launched from a 28-ft fixed ramp, a ramp adjustable in elevation and azimuth is planned for the *Dragon*.



The *Eridan* two-stage probe differs from the other four types in that it is designed for payloads varying between 130 and 700 lb in weight; the others, with their common *Bélier* final stage, all carry a 70 lb payload. The *Eridan* — without its measurement head, of course — is the booster for the three-stage *Pégase* pictured below. ◀



The largest and most important member of Sud-Aviation's family of probes, *Pégase*. This is the only one of the family whose first stage includes a remote control system for certain flight path corrections. This is however only for the first phase of the rocket's flight and, after first stage burnout, it separates from the rocket with the first stage. ▶

The Pégase

Pégase is the designation of the largest rocket in the family of probes; it is a three-stage rocket, whose final stage is again a suitably adapted *Bélier*, including the standardized rocket head. It is understood that the *Pégase* will be able to reach ceilings in the neighbourhood of 625 miles and, as is also true of all the other probes mentioned in this article, the payload can be recovered.

The first stage of the *Pégase* uses a solid propellant rocket engine of the *Stromboli* type. Unlike the foregoing probes, the four stabilization fins of the first stage are adjustable and the first stage also has remote control equipment. In this way, the flight path of the *Pégase* can be corrected by the ground station in the first phase of flight i.e. immediately after launch. In the initial phase of flight, the stabilization of the probe is ensured by remote control. The first stage, however, carries neither antennas nor auxiliary control rockets.

After first stage burnout and separation, flight proceeds as for the *Dragon*. In reality, the second and third stages of the *Pégase* are no more than a suitably adapted *Dragon*, again incorporating a *Bélier* as the final stage.

For launching the *Pégase*, a ramp adjustable in elevation and in azimuth is used. Although the probe weighs over two tons and exceeds 33 ft in length; maintenance, handling and launch are surprisingly simple.

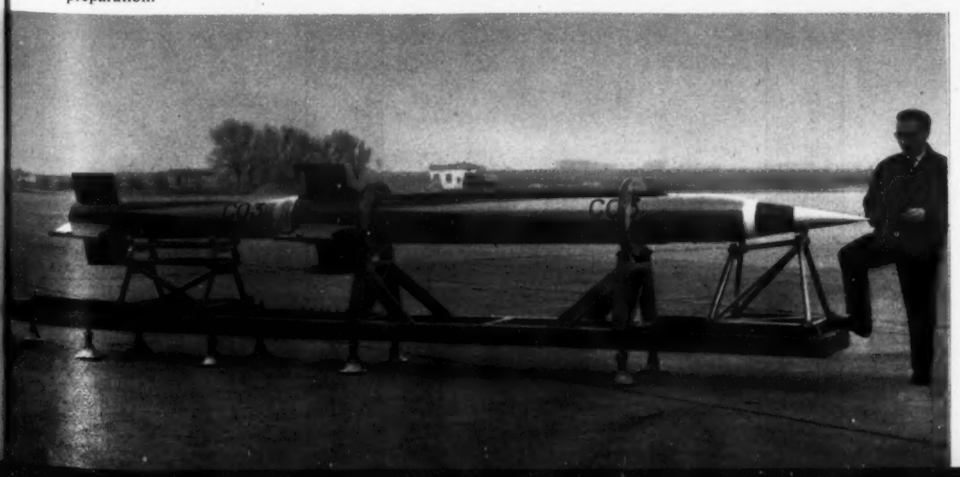
The Eridan

This two-stage rocket with solid propellant is an "outsider" to the Sud-Aviation family of probes. Both stages are fitted with *Stromboli* motors. Like the three types mentioned earlier in this article, the *Eridan* has no remote control system whatever. Auxiliary rocket engines at the stabilization surfaces and slight displacement of the final stage control surfaces suffice to provide this rocket with the roll necessary for longitudinal stabilization.

The main difference between the *Eridan* and the other rockets mentioned here is that the *Eridan* is not fitted with the standard rocket head for a 70-lb payload, but is designed to carry varying payloads of 130 to 700 lb. From the fact that the *Eridan* can carry such respectable payloads to a maximum ceiling of several hundred kilometers, the possibility of using several of these probes or combinations of them as part of a large-scale space research programme is obvious.

All in all, the optimism of the Colomb-Béchar scientists charged with carrying out the altitude research programme seems justified. Research carried out at the European level, and accompanied by a liberal exchange of experience, could do a lot towards fulfilling the desire for European science to be more independent in the space field, too. ◆◆

The *Centaure* two-stage sounding rocket on its assembly rig. All the Sud-Aviation probes are characterized by extreme simplicity of construction, only a minimum of auxiliary equipment being required for maintenance, handling, and launch preparation.



What's in the Air?

The U.S.Army Transportation Corps is optimistic about tests carried out to date on the *Flex Wing* or *Fabric Wing* developed by Ryan Aerospace Division of Ryan Aeronautical Company. Ryan is working on various designs and one powered vehicle used in the Army trials is shown here. Construction details can be clearly seen, with the leading edge spar and central main spar supported by a simple lattice-work construction. The flexible membrane is constructed of plastic-impregnated nylon fabric. The wing offers an extremely lightweight, large aerodynamic lift surface permitting major simplification in control system design and may be packaged compactly for rapid deployment for various missions. The design is based on an original concept by NASA's Dr. Francis Rogallo.

The Army is interested in both a possible combination parachute-glider for air-dropping *matériel* and troops, and a powered version with conventional aircraft take-off and landing characteristics. Such a vehicle would have high payload ratio, would be relatively simple to control except in high wind, and would be extremely economical to build and maintain. At least another twelve months' testing is indicated before any firm Army evaluation is made. This Rogallo/Ryan wing concept is being examined by other U.S. Federal agencies for possible use as a rocket booster recovery device and also as a retractable auxiliary wing for high-speed aircraft.

Wings of this design have already been put through extensive free flight and wind tunnel tests at Langley Field. Wind tunnel tests have been carried out up to Mach 4.9 and simulated flight altitudes of up to some 37 miles, and further tests are scheduled.

The first Aviation Traders' ATL-98 *Carvair* made its maiden flight from Southend Airport towards the end of June. Ten of the aircraft are on order for British United Airways' subsidiary company, Channel Air Bridge, and the first will go into service this autumn, transporting passengers and automobiles from the U.K. to continental Europe. The *Carvair* is basically a Douglas DC-4 with an entirely new forward section, extending length by 12 ft and fitted with a nose-opening door for loading five medium-size automobiles into the freight hold below the raised flight deck. The basic passenger/car-ferry version has accommodation for 23 passengers at the rear of the fuselage. Aviation Traders is offering the *Carvair* for £150,000 and the conversion can be carried out on any DC-4. Payload and cruising speed are higher than the Bristol *Freighter* but operating costs are about the same. Maximum speed at 73,000 lb is the same as the DC-4's. Cruising speed is 174 knots at 65,000 lb AUW. Span 117 ft 6 in. Overall length 102 ft 7 in. Height 29 ft 10 in. Maximum length of freight hold 81 ft 2 in. Takeoff distance at sea level and 73,800 lb AUW is 5,300 ft. Landing distance from 50 ft at 64,000 lb is 2,800 ft (at sea level and ISA conditions).

General Dynamics/Convair had completed 400 hours flying with three Convair 990s in the test programme by early July. First deliveries to airline customers are scheduled for late September—early October with aircraft numbers 1, 2, 3, 4 and 6 going to American Airlines (25 on order) and numbers 5 and 7 will be the first two delivered to meet the Swissair-SAS order for seven aircraft (SAS has ordered another two Convair 990s on its own account). The Convair order book for the 990 currently stands at 37 aircraft. FAA certification is promised for December this year, but provisional certification will be available for pilot training with first deliveries to American Airlines and Swissair.

For interim operation, until the 990s are available, Swissair will have two Convair 880s on lease with deliveries now scheduled for August 7th and August 15th.

Saab Aircraft Company's new F-version of the 35 *Draken* will be equipped with both radar and infra-red homing versions of the Hughes *Falcon* air-to-air missile, a new version of Saab's collision course fire-control system (S7) and a more efficient type of radar, also of Swedish design. In Sweden, the *Falcon* carries the designation RB 327 with radar homing and RB 328 with infra-red homing head.

Other new versions of the *Draken* recently announced by Saab are the 35D equipped with the S7 fire-control system and powered by a Rolls-Royce RB. 146R jet engine built under licence by Svenska Flygmotor, and the 35E, recently ordered by the Swedish Air Force for reconnaissance work. Saab says that the 35D *Draken,* the earlier 35B version, and the two-seat 35C trainer version, are all expected to come into service during 1961. The new Saab 35F version, already on order for the Swedish Air Force, will probably be produced in greater quantities than any of the earlier versions. Saab plans further developments in terms of armament, performance, and equipment, and production of these later versions is expected to carry over well into 1968.

The U.S.Navy's newest weapon system, the North American A3J *Vigilante*, is currently being delivered to the Sanford (Florida) Naval Air Station for fleet assignment. The A3J carries a crew of two (pilot and bombardier-navigator) and has a speed of Mach 2. Last December, the A3J set up a world altitude record of 91,450.8 ft for jet aircraft carrying a 2,204 lb load.

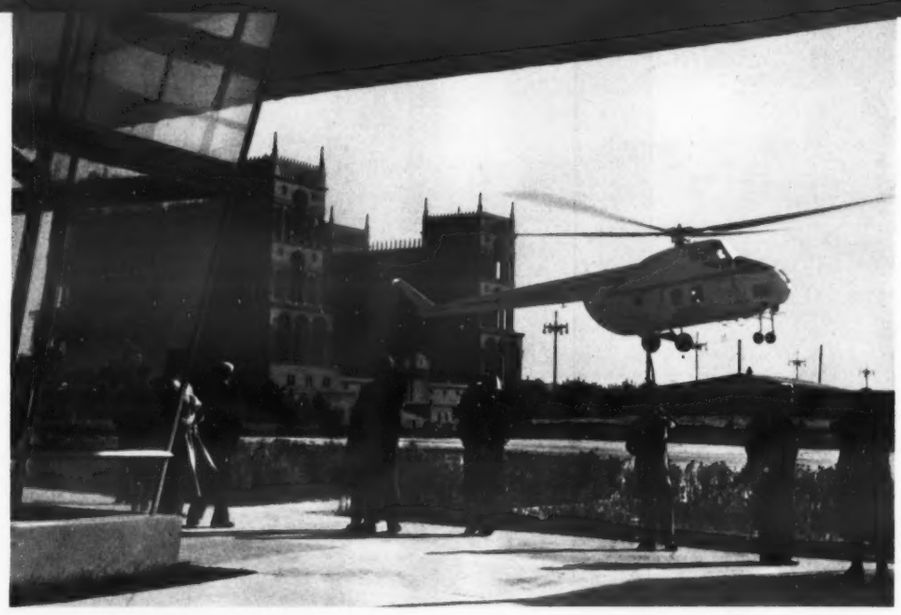
The U.S. Army Transportation Research Command used the recent *Project Mobility* exercise at Fort Eustis, Virginia, to demonstrate an experimental rocket lift device to achieve individual controlled free flight over the ground. Development and testing of the Small Rocket Lift Device (SRLD) has been under way at Bell Aerosystems Company for the past nine months under a Trecom contract, and over 30 flights have been successfully carried out at the company's Buffalo plant. Test engineer Harold M. Graham has flown distances of up to 360 ft with the SRLD and in one flight used the device to fly to the top of a 30-ft hill. No attempts have been made to achieve maximum speed but average speed on a test run was estimated at 20 m.p.h.

Basically, the device consists of a twin jet, hydrogen peroxide propulsion system mounted on a fibreglass corset moulded to fit the back and hips of the operator. Padded lift rings go over the operator's arms and the unit is secured with two quick-release safety belts around the abdomen. Metal control tubes attached to the lift rings extend forward on each side of the operator. A control stick mounted on one tube permits change of flight direction. A motorcycle-type hand throttle on the other tube regulates rocket thrust levels controlling rate of climb and descent. In flight, the device has been found so stable that pitch and roll are easily controlled by movements of the operator's body. The rocket propulsion system is fully controllable. Hydrogen peroxide is forced under pressure into a gas generator, where it contacts a catalyst and decomposes into steam which is directed through two rocket nozzles to provide thrust. Main thrust is directed towards the ground with jet deflectors providing thrust for yaw control. No special protective garments are required for the operator.

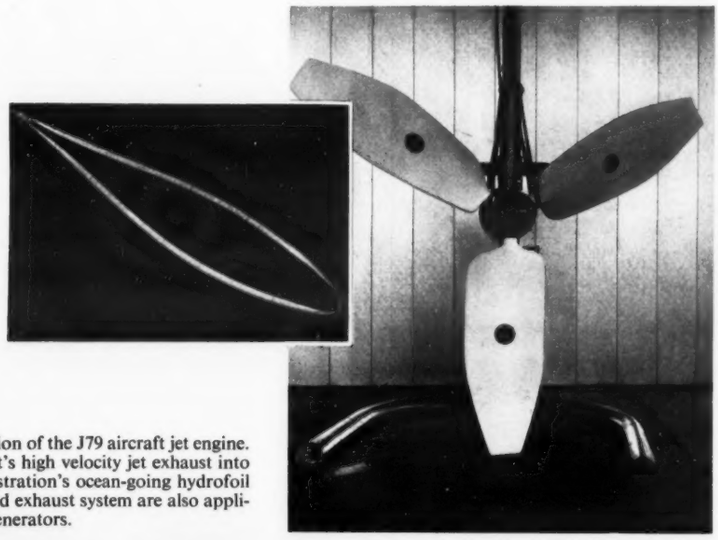
The Boeing B-52H with *Skybolt* ALBMs is the USAF Strategic Air Command's newest global weapon system, currently under development for operational use in 1964. Compatibility testing has been carried out at Boeing's Wichita Division. The new H-model has eight Pratt & Whitney TF33-P-1 turbofan engines, and range will be considerably increased over the 10,000-miles offered by the B-52G. The 450,000-lb B-52H will mount four long-range, hypersonic, Douglas *Skybolt* nuclear-tipped ballistic missiles in addition to nuclear weapons carried in the bomb bay.

Sikorsky Aircraft Division of United Aircraft Corp. has carried out a design study of a high-performance helicopter with a 2-ton payload capacity at cruising speeds of up to 200 m.p.h., under a U.S. Army Transportation Research Command contract. Costs have been shared jointly by the Army and Sikorsky and the new design is largely based on the dynamic components of the HSS-2 (S-61). The contract specifies an aircraft with a conventional single main rotor, a ferry range of 1,840 miles, and a forward speed of 200 m.p.h. Sikorsky says that the objectives can be met, and in some cases exceeded. Analysis of the design shows a ferry range of 2,400 miles and a top speed without payload of 224 m.p.h. The Sikorsky high-performance design has a payload of 4,000 lb and a cruise speed of 201 m.p.h. for a range of 150 miles. Payload can be increased to 7,000 lb by cutting cruise speed to 173 m.p.h.

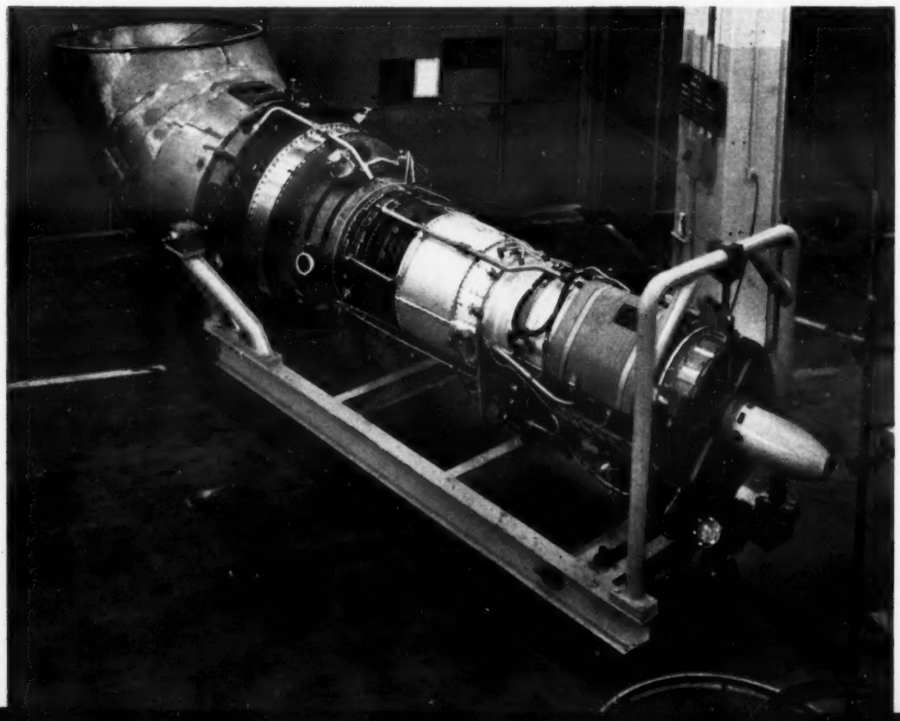
The design features: a new low-drag fuselage with completely retractable main and tail landing gear; a rotor head fairing system to minimize the drag of the main rotor head and pylon; a fixed vertical stabilizer and rudder, and a large horizontal tail with elevator for longitudinal trim control. The fuselage has space for 20 troops. The powerplant system is essentially the same as that used on the Sikorsky S-61 helicopter, including General Electric T-58 twin turbine engines and five-bladed main rotor.



Aeroflot is operating Mil Mi-4P helicopter passenger service between Lenin Square in the centre of Baku to the airport at the new Azerbaijan-Sumghait industrial centre. The Mil Mi-4P shown here in Aeroflot colours has a crew of two and can carry eight to eleven passengers. Powerplant is one ASL-82 V18-cylinder air-cooled radial engine of 1,700 h.p. Maximum speed is 116 m.p.h. at 4,920 ft. Cruising speed 93 m.p.h. Service ceiling 10,000 ft. Range 155 miles.



The General Electric Model 240 turboshaft engine shown here is a sea-going version of the J79 aircraft jet engine. The principal modification is the addition of a power turbine to convert the unit's high velocity jet exhaust into shaft horsepower. The Model 240 engine will power the U.S. Maritime Administration's ocean-going hydrofoil vessel scheduled for testing this summer. Various configurations of the engine and exhaust system are also applicable for use in mobile electric power systems and as prime movers for power generators.



Curtiss-Wright Corporation's Propeller Division (Caldwell, N.J.) has developed a new, lightweight, low-cost propeller for VTOL applications. The seamless blades are constructed of fibreglass-reinforced plastic to give both weight reduction and the required strength and aerodynamic capability. The Curtiss-Wright test programme, including actual flight on the company's VTOL prototype, has reached a stage where prototype and production orders are being sought.

Blade weight reduction in the order of 50 percent can be achieved compared to conventional hollow steel or solid dural blades. De-icing equipment can be built into the material providing an aerodynamically-clean installation. The primary load-carrying member is the reinforced plastic monocoque outboard blade section which transfers loads to the steel shank blade root. Blade walls are made of epoxy resin-impregnated, selectively oriented woven glass fibres. Steel blade roots are bell-shaped, heat-treated die forgings.

Curtiss-Wright's studies were launched in 1956 and work on the current seamless designs was started in February 1958. The new blades were subjected to wind tunnel tests in September 1958, and tests on the Curtiss-Wright Gyroscopic 1 × P test rig were carried out from October to December. In January 1959, the blades were tested on the model 100 VTOL flight test aircraft and the second, larger design was being initiated.

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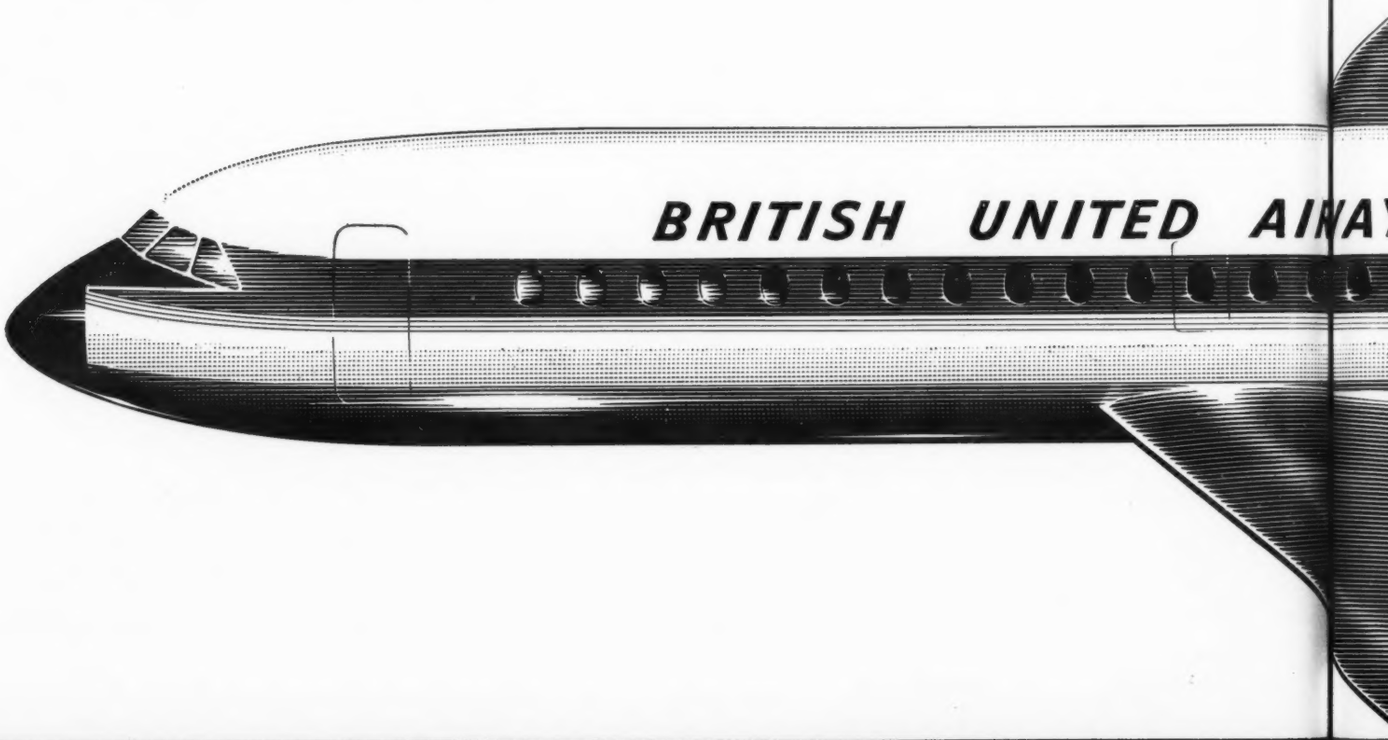

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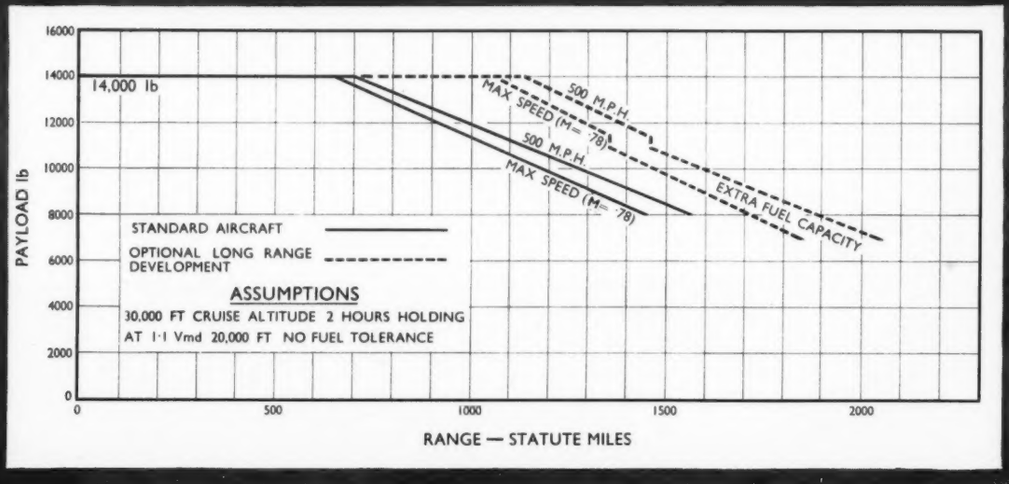

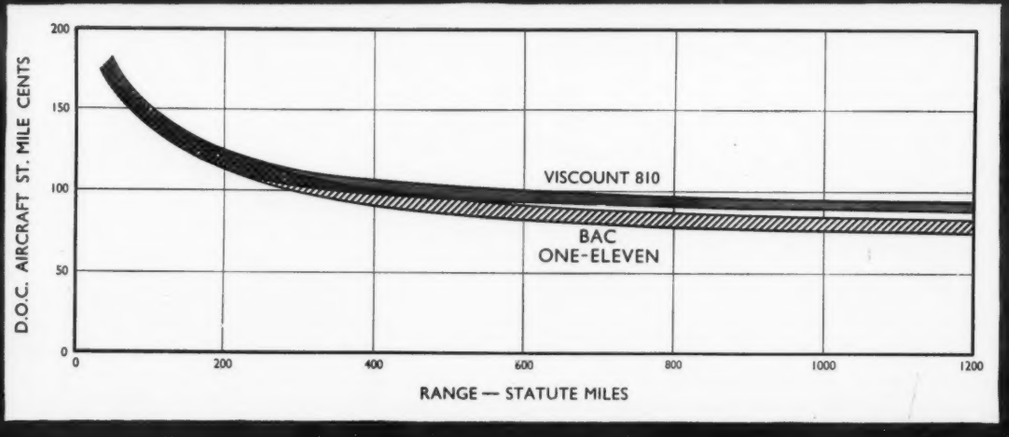

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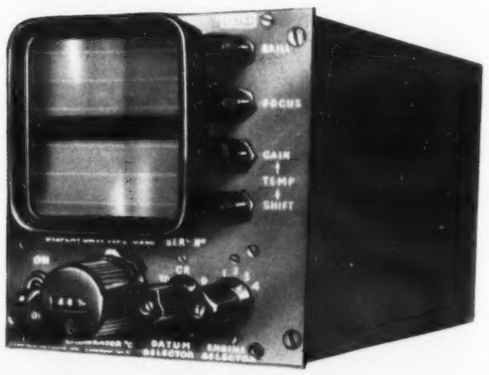
Electronics in Aviation and Industry

Research and Production News

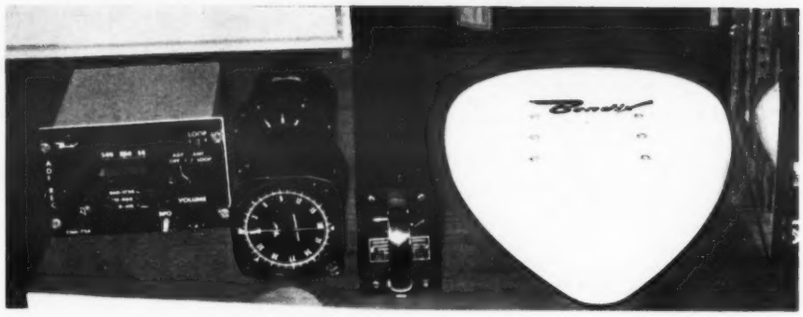
The items described here continue the selection of electronic equipment from the Paris Air Show, commenced in Interavia 7/1961

• **Ultra Electronics Ltd., London** has developed a new engine condition analyzer, designated UE91, which indicates engine temperature and vibration conditions on two comparative scales. The instrument can be used for pre-takeoff checking, in-flight analysis, and routine maintenance. It detects, for example, any variation in engine temperature or excessive vibration in its earliest stages. The instrument is fully transistorized, has no moving parts, and can be easily switched to the sensing element of any engine. A first order has already been placed by BOAC, which plans to instal this analyzer in its *Comets*.



• **Litton Industries, Beverly Hills, California** featured its extensive production programme which, among other items, includes the LN-3 inertial navigation system used in the Lockheed F-104 ordered by Canada and several European nations. This 80-lb inertial navigator manufactured by the Guidance and Control Systems Division of Litton Industries, Inc., operates with an average error of 1.5 n.m. per flight hour. This concern also produces the LN-2C inertial navigation system for the US Navy Lockheed P3V-1 patrol aircraft. By combining the LN-2C inertial navigator with the AN/APN-122 airborne Doppler, position can be determined with a high degree of accuracy (circular error probability of less than two miles per flight hour). Moreover, the Doppler system can be used for in-flight alignment of the inertial navigator, and thus for establishing new data for further navigation. The photo shows, from left to right: the LN-2C inertial system computer, the power pack, the gyro platform, its electronic gear, the Doppler apparatus, the position indicator, and the control equipment.

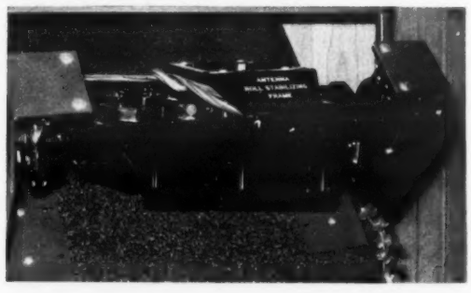
• **Crouzet, Valence, France,** showed the 301 Dead Reckoning Automatic Navigator which is designed primarily for mounting on light and medium anti-submarine aircraft (such as the Breguet *Alizé*) but is also suitable for use in civil aircraft. The automatic navigator may be used on aircraft with airspeeds up to 400 knots, and its operation requires only a setting of the initial coordinates before departure. During the flight it provides continuous automatic indication of the actual position coordinates, in either of two manners. When set to "air," the equipment calculates the position based only on true airspeed, heading, and time, and indicates the relative position of the aircraft only. When set to "ground," the wind speed and direction, as well as outside temperature, are taken into account, so that the true position is indicated in relation to the ground. Position data may either be read off on a combined visual display unit, which gives a numerical presentation, or on a special pictorial position tracer, which has two scales available: 1 : 500,000 for reconnaissance missions, and 1 : 100,000 for combat missions. There is a separate instrument for displaying the aircraft's position independent of geographical coordinates on any desired grid.



• **The Bendix Corporation, Eclipse-Pioneer Division, Teterboro, New Jersey,** has developed the VERNAV (Vertical Navigation System), which should prove especially valuable to jet aircraft pilots. The equipment consists of an airborne computer, a control unit, and a vertical data display unit. The computer uses DME data, airspeed, and rate of climb or descent of the aircraft to determine an exact vertical flight path from the position and height of the aircraft at any given moment to any desired aim point, which can be either over a DME station or at an offset point in space whose position is either arbitrarily selected or given by ATC. The following data are displayed to the pilot in digital form: the distance covered (up to 200 n.m.) from the starting point, the time required to reach the selected aim point (up to 60 minutes), the ground speed (up to 800 knots), the flight path angle (±90°), and the letdown angle (0°-90°). On the basis of this data, the pilot can navigate in the vertical plane, in a similar way to the horizontal, which contributes to increased safety and reduced fuel consumption. As Bendix emphasizes, the VERNAV can be used not only for the approach, but also for the climbout. In cruise flight too, the VERNAV renders valuable services not only by indicating distance or, as the case may be, the flight time required to reach a VOR, DME, VORTAC, or TACAN station, but also the altitude change. At the Salon, Bendix also exhibited its new DFA-72 radiocompass (see photo), featuring light weight and high reliability, which completes the "Series 22" radio navigation equipment.

• **Standard Telephone and Cables Limited (STC), London** was represented in Paris at the joint stand of eight European firms in the ITT group. Its exhibit included, amongst other items, a written and pictorial description of the advantages of the now fully developed PVT.2 triangulation direction finder system. The PVT.2 is a further development of the PVT.1 direction finder, which has served for years in many countries, and includes the same basic equipment as its predecessor; a new readout display has however been provided. Although it was developed specially for use with the CADF (Commutated Antenna Direction Finder) system manufactured by this Company, it can also be used as a display unit for other types of ground-based direction finders. By means of telephone or radio links, the directional data from a maximum of 12 DF stations, after being picked up from air-to-ground R/T signals, is automatically transmitted to a central "triangulation picture synthesizer" and presented on a corresponding number of small cathode-ray tubes. This image, combined with a map, is then led into a closed TV circuit and reproduced on a screen, e.g. in an ATC centre. In the photo, the three bearings giving the exact position of the aircraft are displayed on the screen.

• **Canadian Marconi Company (CMC), Montreal,** exhibited its well-known Series CMC-620 Doppler navigation system at the Paris Air Show, citing its outstanding performance record over thousands of flight hours logged aboard both civil and military aircraft. In the face of the widespread tendency towards transistorization of electronic equipment, CMC continues as heretofore, to use tubes. In this connection, particular stress is laid on the fact that, to date, not a single Doppler navigation system failure has been traceable to a defective electron tube. Instead of the CMA-623 Doppler antenna (frequency 8,800 Mc/s: weight 30 lb) in use until now, the Canadian Marconi Company offers a new, improved antenna, much smaller, operating on 13,250 Mc/s and weighing only 17 lb, yet of equal precision. As one of the advantages of this antenna, it is stressed that no mechanical adjustment is required in mounting or maintenance, and that it is automatically stabilized against aircraft pitch and roll up to a maximum of 30°. In addition, this antenna may be mounted on a stabilized frame (see picture), which allows its movement about the various motion axes of the aircraft as follows: roll, up to 70°; pitch, up to 15°; yaw, up to 40° (drift angle). It was further learnt that this firm is working on a new Doppler device of considerably higher precision, which will, for example, measure ground speed with a maximum error of 0.1 percent (as compared with 0.8 percent in the case of the CMA-623).



• **Lear Electronic GmbH, Munich,** put its new ADF-102 radiocompass on view for the first time. This is a fully-transistorized goniometer with a frequency range from 190 to 1,600 Kc/s, which combines the functions of an airborne receiver and a radio direction finder. Two frequency ranges can be used in tuning, and there is push-button selection of five pre-selected frequencies.

• **Aircraft Radio Corporation (ARC) of Boonton, New Jersey** featured the advantages of its three radio navigation systems marketed under the name of *Starflite*. *Starflite I* comprises a number of remotely controllable devices together with the corresponding display instruments, and is primarily intended for large passenger and cargo aircraft. In addition to the several items of ARC equipment which have stood the test of operation over a long period, the *Starflite I* includes new antennae, a transmitter/receiver, and the new B-19, converter with its associated IN-16A indicator, which supplies both LF/MF and VOR bearings together with the magnetic heading of the aircraft. The *Starflite I* also incorporates the simplified new CD-4 navigation system (see illustration) which uses only a single IN-14 indicator for VOR. LOC, ADF and magnetic heading.

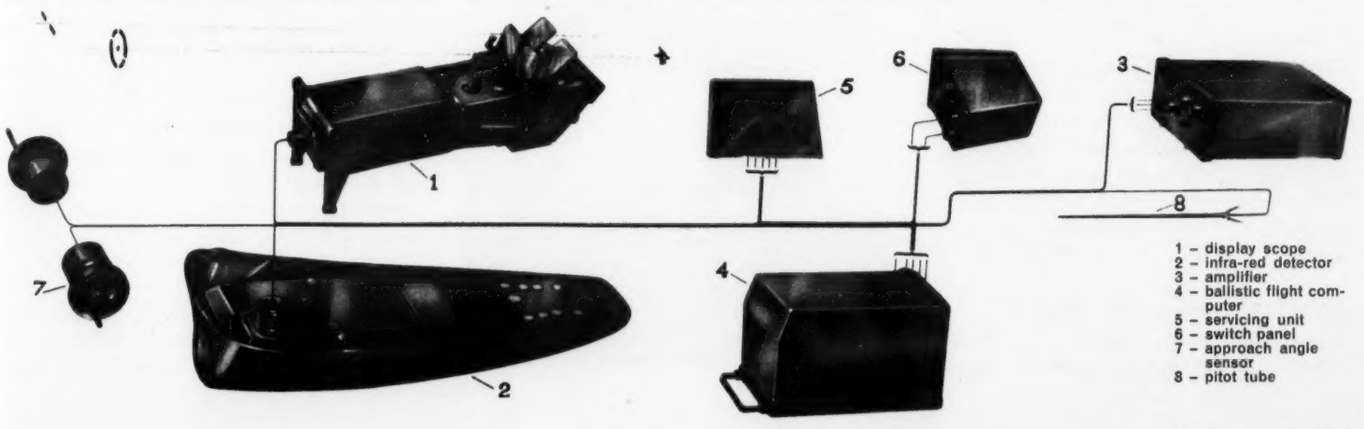
The newly-developed *Starflite II* is designed mainly for light twin-engine or large single-engine aircraft. It consists of a radio compass and a complete communications and navigation installation. The individual units are manually controlled and can be fitted into the instrument panel. The *Starflite III* equipment, which was developed as a communications and navigation aid for use in light aircraft, is designed for mounting on the instrument panel.

• **Collins Radio Company, Dallas, Texas** called particular attention at the Paris Air Show to its new 618T airborne transmitter/receiver for high-frequency SSB use, with 28,000 channels available in the range from 2 to 30 Mc/s, peak envelope power of 400 watts in SSB use, and providing a 100 watt carrier for conventional AM operation. The WP-103 airborne weather radar was also prominently displayed on the Collins' stand. This device not only makes it possible to detect foul weather and storm centres lying ahead, but can also be used to display the terrain below. The WP-103 works with pulse-modulation in the X-band. With its 20 kW pulse output, it has a range of 175 miles. The display is presented either on a conventional 493A-4 scope or on the newly-developed 493-3 daylight screen (see picture). The latter requires no special hood and allows simultaneous observation by pilot and co-pilot.

• **Svenska Aeroplan Aktiebolaget (SAAB), Linköping,** exhibited at Le Bourget, amongst other items, the FH5 Automatic Flight Control System, which was developed for the SAAB *Draken* and meets all the requirements of modern supersonic fighters. The FH5 stabilizes the aircraft about all three axes, and can in addition be used as a special stabilizing aid when flying under manual control. This system uses input data supplied by the flight data computer and a gyroplatform. In addition to the normal functions, the improved FH5 may be used to maintain a specific flight altitude as well as a selected Mach number. During automatic flight control, the pilot can change the aircraft's attitude either by means of the trin control knobs provided on the console and/or by moving the control stick, which then no longer acts directly on the aircraft's control surfaces, but on the FH5 flight control system to which it is linked.

The SAAB S6 all-weather gunsight (picture) and the SAAB S7 fire-control system were also among the items illustrated on the SAAB Stand. The S6 gunsight is an all-purpose device which can be used in pursuit and interception missions against air targets with cannon, rockets, or guided missiles, or against ground targets with cannon or rockets. For interception missions by night or in cloud, the pilot has available a synthetic display of the target information, derived either from the airborne radar or from the infra-red search equipment. All the necessary information is shown at the pilot's eye-level, except for the target distance indication, which is given by characteristic pitch variations of an acoustic signal in the pilot's headset.

The SAAB S7 fire-control system is their very latest development and shrouded in secrecy. Although designed primarily for collision course air-to-air combat missions, the S7 is in fact all-purpose equipment, which can be used as a part of the overall weapons system of an aircraft, for a variety of other missions. Its input is provided by the airborne radar, the flight data computer, and the main gyro unit. A display unit provides the pilot with all the necessary steering information for attack The computer determines the exact moment for firing the aircraft weapons and automatically fires them as soon as the aircraft is at the proper distance from the target. After firing, the pilot is warned when to change course. There is also a special version of the S7 designed for use with the Hughes *Falcon*, the air-to-air guided missile ordered by Sweden. This version, however, entails various modifications, including a more powerful airborne radar. The modified S7 makes it possible to use the *Falcon* with either a radar or an infra-red homing head.



Electronics

In Mass Production
at Ryan Electronics

Doppler Navigation Systems for Helicopters

Self-contained Doppler navigators endow helicopters with all-weather capability — an indispensable requirement for use of helicopters as military weapons systems.

Ryan Electronics, a Division of the Ryan Aeronautical Company in San Diego, California, has over the last 15 years been engaged in the development and manufacture of electronic equipment and systems. The firm is pursuing an extensive research and production programme and is contributing to the solution of various problems in the aviation and space travel fields. A few of the Ryan Electronics Division's activities include: soft lunar landings, rendezvous terminal guidance, electronic countermeasures and counter-counter-measures, IFF equipment (Identification Friend or Foe), ASW weapon systems (antisubmarine warfare), radar altimeters and landing aids, continuous-wave (CW) and pulse radar techniques, and digital and analog data processing.

In the course of fifteen years of continuous development work, Ryan has achieved notable success in the field of Doppler navigation. The firm's publications stress the fact that it is now the world's largest producer of CW Doppler navigators and that it was the first to concern itself with Doppler systems especially tailored to meet helicopter requirements. In addition, Ryan manufactures the newly-introduced RYANAV IV universal Doppler navigator, applicable to all types of aircraft for all speed ranges and all altitudes.

Derived from the AN/APN-22(V) and AN/APN-129(V) Doppler sets with which numerous types of US Army and US Navy aircraft are equipped, the Doppler navigators for helicopters are already in widespread use. There are several thousand units of all types now on order for installation on more than 25 different types of aircraft.

Helicopter Navigation Requirements

The significance of the helicopter as a weapons system is gaining growing recognition not only in the United States, but in NATO countries as well. The suitability of rotary-wing aircraft for various military duties has long been recognized, but limitations on their use due to navigational difficulties have thwarted their wider acceptance by the armed forces. For example, at night and in bad weather, helicopter operations are either impossible or severely restricted. In other words, the helicopter lacks blind-flying capability.

Among the main advantages of the helicopter is its ability to hover motionless, to rise or descend vertically, and to move forward or backward at near-zero velocity. In this mode of flight, however, wind effects are very noticeable, and some means are required to counteract these effects. Once the helicopter has been provided with all-weather navigation equipment it would be transformed into a valuable military weapon.

A US Navy Sikorsky HSS-2 helicopter on an antisubmarine warfare mission. The cable used to lower the sonar device for submarine detection can be seen.

Antisubmarine Warfare

The use of helicopters for antisubmarine warfare (ASW) constitutes a typical example of the use of helicopters as a modern means of defence.

A ship-based ASW helicopter sets out for the predetermined patrol area, and upon arrival at the assigned duty station, it hovers steadily (often in the company of other helicopters) during the time required to lower and operate the sonar probe. This procedure is repeated a number of times, the distance between probe dips being dependent on the range of the sonar gear. When a submarine is detected, the finder aircraft holds contact and follows it until other helicopters arrive to attack the submarine with suitable weapons. Upon completion of the search, or destruction of the submarine, the helicopter returns to its carrier. Since submarines operate in foul as well as fair weather, it is self-evident that the means deployed to combat them must be usable under all weather conditions.

In this short description of ASW methods, no attempt will be made to draw up a comprehensive list of all the performance requirements of ASW helicopter navigation equipment, although they apply in varying degrees to all military equipment of this class. The more important of these requirements are:

- precise navigation under all weather conditions
- independence from ground radar and other land-based or shipboard radio navigation aids
- true position and flight altitude indication
- compensation of wind effects in hovering as well as in vertical and negative speed flight
- minimum weight
- simple maintenance
- maximum reliability and guaranteed performance

In addition, it is desirable, and in many cases necessary, for the output from the airborne navigation system to be supplied to the helicopter

Automatic Stabilization Equipment (ASE). This further reduces the workload on the pilot, who can thus concentrate on the other phases of his mission.

The airborne Doppler navigation system largely fulfills these requirements, and its operation and construction is well-suited to the special needs of helicopters. Although these Doppler navigators are today standard equipment on many civil and military aircraft, they do not lend themselves to the solution of all the problems posed by helicopters without adaptation.

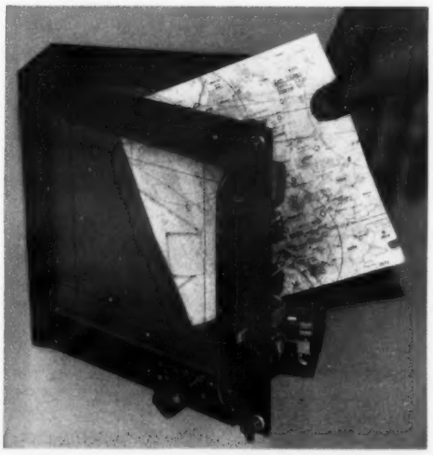
Upon departure, the helicopter pilot first selects the heading and ground speed, and then by taking the drift velocity into account he can be assured of maintaining the desired course. While the helicopter is automatically flying to the first search area, the pilot simply monitors flight progress on his navigation instruments. Upon arrival at his duty station, he switches over to hover flight at a given altitude, and this transition from cruise to hovering flight is automatically effected. The Doppler equipment maintains the hovering helicopter exactly in the desired position and at the right height. The transition from directional flight to hover flight by means of Doppler and ASE equipment presents no problems, as experience has demonstrated; likewise, automatic hovering flight has proven practical. Automatic directional flight using the Doppler system has also been successfully conducted in ASW missions.

Device for pictorial display of position and heading. The indication is given by an aircraft silhouette symbol whose position and movement are controlled by the Doppler navigator output.

▶

◀

Helicopter hovering indicator. By suitable maneuvering, the pilot keeps the horizontal and vertical bars (indicating the heading velocity and drift velocity) crossed in the middle, and the pointer on the left side of the instrument (indicating the vertical velocity) at the zero position in the middle of the scale. The input to the instrument consists of the Doppler-determined velocities.



The Ryan Electronics Doppler system for helicopters

Three basic techniques are used in Doppler systems: pulse-modulated or frequency-modulated continuous-wave (PM/CW or FM/CW) and pure continuous-wave (CW) techniques. Highly effective PM/CW and FM/CW Doppler equipment is currently being offered by a number of firms. After thorough study and research, Ryan decided to concentrate on the pure CW technique, which presents special advantages for helicopter navigation equipment.

As early as 1957, Ryan produced the AN/APN-97, which constituted the first Doppler equipment for helicopters. The improved AN/APN-97A version is today in wide use on combat aircraft of the United States, particularly in anti-submarine warfare helicopters. In the United Kingdom and in the Netherlands a number of helicopters are also being fitted with this equipment.

The AN/APN-97A is a light, compact and self-contained airborne Doppler system, especially designed for helicopter hovering at low altitudes. Its sensitivity to motion is such that it accurately detects the velocity of a hovering helicopter down to a threshold of one-half knot, so that the pilot is able to maintain any desired position in the air very precisely either manually, or through the autopilot.

Through its antennas, the AN/APN-97A transmitter radiates four symmetrical beams toward the ground. The waves reflected by the earth's surface reach the receiver with frequency shifts which are proportional to the components of the velocity of movement of the four beams over the ground. The difference between the emitted and received frequency, the so-called Doppler frequency, lies in the low-frequency range, and is determined by the receiver directly from the spectrum of reflected energy. After amplification, it is led to a converter which determines the sign as well as the magnitude of the Doppler signal and transforms the values obtained by arithmetic operations into the form of AC and DC analog voltages. These are directly proportional to the heading, drift, and vertical velocity components of the aircraft.

While the AC voltage (in some cases also the DC voltage) is supplied to ASE, navigational computers, or other equipment to serve in further automatic processing, the DC voltage is fed to the Direction-Velocity Indicator. This device indicates the actual flight velocity of the aircraft along its three axes. In order to maintain the helicopter exactly stationary at a constant altitude, the pilot only has to maneuver so as to keep the horizontal and vertical bars (heading and drift velocities) exactly centered in the middle of the instrument, and to hold the ballpointer on the left side of the dial (vertical velocity) at its zero position.

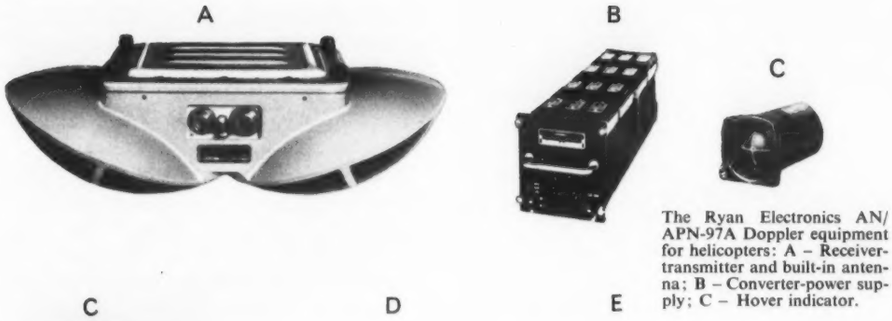
When the AN/APN-97A is coupled with the automatic stabilization equipment (ASE) and an altimeter, the pilot can maneuver completely automatically, from normal cruising through transitions in both speed and altitude to a fully-automatic precision hover, which can be maintained even under poor visibility conditions with greater precision than can be attained manually in clear weather by an experienced helicopter pilot.

The AN/APN-97A antenna is compact and has no moving parts, which greatly enhances its reliability and simplifies maintenance. Better service performance is also ensured by the use of transistors, printed circuits and plug-in sub-assemblies. Finally, the direct processing of the Doppler signal offers the advantage of eliminating the need for an intermediate-frequency amplifier and automatic frequency control (AFC).

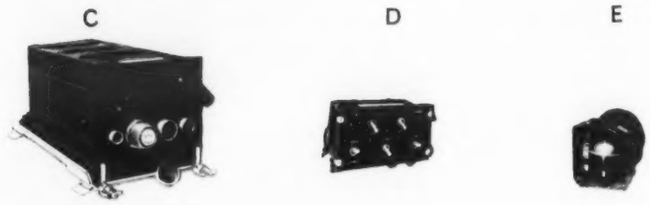
The following are some of the technical characteristics of the AN/APN-97A: transmitter frequency 13,300 Mc/s; beamwidth 5½°; heading speed, drift speed, and ground speed measurement range 0 to ± 150 knots; vertical speed range 0 to 2,000 ft/min; measurement of any drift angle; power consumption less than 170 watts; transmitter power approximately 1 watt; weight 37 lbs.

Now in quantity production, the AN/APN-130 is an advanced CW Doppler navigator especially designed for helicopter use. Among US Navy aircraft on which it will be installed as standard equipment are the Sikorsky HSS-2 and Kaman HU2K-1 helicopters, and its use on other helicopters is presently being evaluated both in the US and in Europe.

Compared to the AN/APN-97A, the AN/APN-130 Doppler equipment provides higher precision, a greater range in vertical velocity measurement (from 0 to 3,500 ft/min), and a higher service

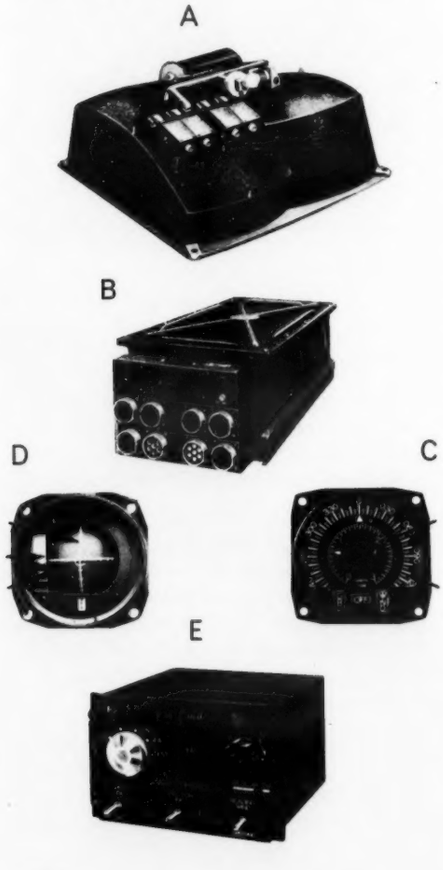


The Ryan Electronics AN/APN-97A Doppler equipment for helicopters: A – Receiver-transmitter and built-in antenna; B – Converter-power supply; C – Hover indicator.



Components of the Ryan AN/APN-130 Doppler navigator for helicopters: A – Receiver-transmitter and antenna; B – Converter; C – Power supply; D – Control unit; E – Hover indicator.

The Ryan RYANAV IV universal Doppler navigator includes: A – Receiver-transmitter with antenna; B – Converter/Computer; C – Air navigation indicator; D – Hovering indicator; E – Control unit.



ceiling (up to 10,000 ft). It features an improved antenna with narrower beamwidths (3°) to reduce errors over extremely smooth seas. The transmitter power is quintupled (5 watts). The equipment weighs 71 lbs; power consumption is 500 watts; the measurement range for heading, drift, and ground speed is 0 to ± 150 knots.

The RYANAV II-F and RYANAV III-A are combinations of a modified AN/APD-97A or AN/APN-130 with a Tactical Pictorial Display device which indicates ground position. This pictorial display considerably simplifies navigation, since the pilot follows his position on an appropriate map and can fly the desired course without difficulty, by simply heading so that the helicopter symbol ("bug") moves along the course line. The background maps can easily be changed, so that the local area of navigation is kept in view. The present position and heading is shown by projection of an aircraft silhouette onto a translucent screen, which carries a scaled coordinate grid and a compass rose. A desired flight track drawn on a transparent overlay can be placed directly on the face of the screen.

The pictorial display device operates with data supplied by a Ground Position Computer which simultaneously provides continuous counter-type displays of east–west and north–south miles traveled. The computer also indicates departures from heading and errors in position, based on the Doppler-supplied heading and drift velocities.

The RYANAV II-F and RYANAV III-A provide an accurate and highly simplified navigational capability for a wide range of applications: land or sea search and rescue, scheduled airline services, ASW missions, mineral deposit exploration, location of casualties in the battle zone, missile firing site support, troop movement, liaison duty, courier service, and so forth.

Both of these sets may be coupled to automatic stabilization equipment (ASE) and to course and distance computing and indicating equipment. By using both the ASE and an altimeter, all helicopter flight manoeuvers can be executed fully-automatically, from normal cruising through the transition phase to a sustained precision hover.

RYANAV IV is the designation of the latest RYAN Electronics development; it is a reliable, lightweight, precise, completely self-contained universal Doppler navigator—the first of its kind according to the manufacturer. It is applicable to all types of aircraft: fixed-wing, rotary-wing, V/STOL, target drones, and airships.

Like all Ryan Doppler systems, the RYANAV-IV utilizes CW techniques on a 13,000 Mc/s frequency. As opposed to the previous sets, the RYANAV IV uses only three beams. Despite its lighter weight (69 lb) and correspondingly reduced power output (consumption from 260 to 400 watts, transmitter power 2 watts) the RYANAV IV indicates the velocity with an accuracy of better than ± ½ knot, and its navigation positional error is less than 0.7 percent of the distance traveled, plus or minus 0.8 nautical mile. In helicopter hovering, it detects a threshold velocity of one-forth knot.

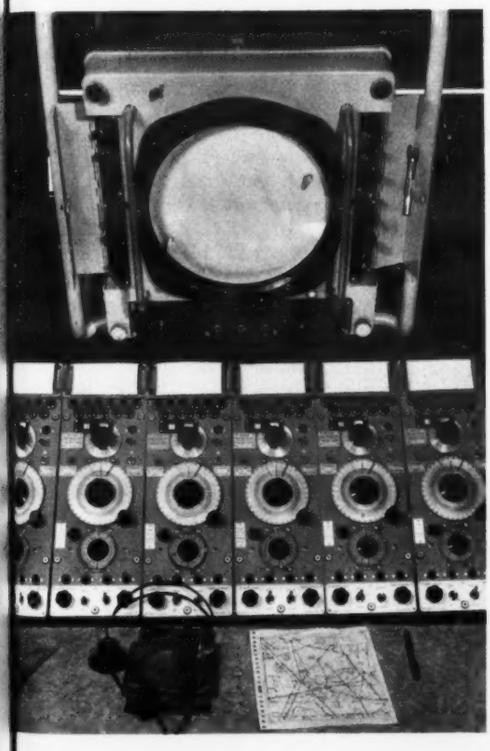
The RYANAV IV also handles a wider range in its measurements: heading and ground velocities from —50 to + 2,000 knots; drift velocity from zero to ± 300 knots; vertical velocities up to 60,000 ft/min; ground track from 0 to 360°; altitude range up to 70,000 feet. The electrical output allows the following data presentation: heading, drift, vertical, and ground speed, ground track, drift angle, true heading, and north–south and east–west distance travelled.

The visual displays include a navigation indicator (ground speed and ground track) and a hovering indicator (heading, drift and vertical velocities); outputs are provided for tie-in to the autopilot, ground track plotters, navigation computers, and automatic stabilization equipment. It is also possible to tie in with inertial navigation equipment, bomb director sets, anti-submarine warfare sets, and terrain clearance radar, as well as with integrated flight systems for aircraft which fly at low and high altitudes.

The RYANAV IV has a fixed-antenna system which requires no adjustments. Hence it can be installed without excessive regard for the structural configuration of a given aircraft, and maintenance requirements are minimized. For higher reliability in service, the equipment incorporates provisions for self-contained functional tests. A system test set, module test set, and test bench harness are provided to facilitate checkout and maintenance. ←

The ANALAC Radar Simulator and Analogue Computer

The four "pilots" working at the S.R.910 radar simulator.



From where he sits, each of the four "pilots" controls the movements of six fictitious aircraft. Aircraft speeds can be selected within a range of 125-1,250 m.p.h. and courses throughout 360°. The "range" of the radar is 340 miles. Pre-programmed or manually set positions are continuously detected and displayed on the console. They are converted by means of a coordinate transformer and shown on the CSF MI 455 fixed coil displays at a speed similar to an antenna rotation speed of 6 r.p.m.

A few weeks ago, an S.R.910 radar simulator produced by ANALAC, a subsidiary of CSF, was put into service at the French National Civil Aviation School at Orly Airport. This simulator, designed and constructed to the specification laid down by the School, is intended in the first place for the training of radar air traffic controllers for the three French air traffic control centres. The system at present comprises 12 PPIs, but further visual equipment can be added at any time. The fact that a maximum of 24 aircraft echoes can be displayed means that an extremely true-to-life image is presented: even rainfall and fixed echoes can be introduced, and the fading of aircraft targets simulated. The movement of aircraft can be controlled in either of two ways. One is by means of the ANALAC K.S.910 analogue computer, in which case movement proceeds in line with a programme for each of the targets to be represented, this being fed in prior to commencement of the exercise. The other is by manual operation, the desired courses and speeds being set on the "pilots," consoles. In normal circumstances, however, a combination of the two methods is used, some of the targets being automatically controlled by the computer, whilst the aircraft to be directed by the pupils is normally controlled by the "pilots" in accordance with the pupils' R/T instructions. One of the great advantages of the simulator in training is that the traffic situation can at any time be frozen, so that important details or mistakes can be discussed. There is also a device for running forwards or backwards and setting the simulator at any desired point in the exercise.

The training of flight controllers is not however the only application for this equipment, which also offers an ideal way of developing and testing new procedures for the radar control of any desired airspace. A further application of the system is the investigation of conflicts and other special occurences, which can be reconstructed with the aid of the S.R.910.

*

The A 101 analogue computer system by ANALAC works on the same principle as the K.S.910 computer of the radar simulator. Instead of d.c. amplifiers, ANALAC computers use exclusively calculation components (high frequency process) and, therefore, contain neither tubes nor transistors. The advantages of this are said to be particularly high stability and fidelity of reproduction, as well as the reversibility of calculation processes. To this should be added the ability to solve systems of implicit equations, which means that the use of computers of this type is not confined to explicit differential and integral equations. The system of removable and independent functional "bricks" gives the ANALAC computers remarkable versatility and adaptability, and in many cases they can, therefore, also be operated by non-specialists. ←→

Picture of the A 101 universal computer installed in the ANALAC computer centre, which gives a clear idea of its construction. The individual computer "bricks" can be combined and linked, as necessary, to suit the problem to be solved. All variables are represented by translation-type servo-multipliers with up to 5 multiplying channels each. The ANALAC computer centre in Paris, equipped with both the A 101 pictured here and an A 110, was established in January, 1961, and its services are available to official organizations and to industrial concerns in all fields.

The Pilots' View of Airport Lighting

By G. R. Stroud

The advent of larger, and faster landing aircraft has driven home the importance of the part played by lighting aids in the safe approach and landing of aircraft. This has led to a good deal of research on this subject in the post-war period but unfortunately not as yet to the adoption of a standardized international system.

Indeed, the variety of aids offered has become a matter of growing concern to the Member Associations of the International Federation of Airline Pilots, and the problem was discussed at the AGA study Group Meeting held at Amsterdam in April of last year. It was then agreed that, in the interests of safety, the differences of opinion must be resolved in order to determine a standard form of approach and runway lighting to be presented by IFALPA at the ICAO Visual Aids Panel Meeting to be held in the following November.

To this end, a questionnaire based on three Approach Systems currently in use, namely the British Calvert System, the United States ALPA Configuration A and the Dutch Integrated Lighting System and Runway Lighting System was sent to the Member Associations, where it aroused much interest and support. The questionnaire did not, however, deal with light characteristics in terms of vertical and horizontal beam spreads (which, coupled with angles of projection and in azimuth, determine the all-important areas of coverage given) and colours. Peak intensities, which depend to a large extent on local meteorological conditions, do not lend themselves to standardization and were for this reason not covered by the questionnaire.

Approach Lighting

As expected, the replies to the questionnaire confirmed that no Association was in favour of continuation of the present multiplicity of systems. The majority favoured the adoption of a single system, with minor, but not fundamental, modifications permitted.

More Associations were familiar with the Calvert System than with either of the other two, and, in a simple reply as to the system preferred, the majority favoured Calvert and none the Dutch.

To the questions "What minor improvements do you consider are necessary to the system of your choice?" and "Why?", the Calvert supporters propose the fitting of strobe lights to improve the clarity and to add emphasis to the system as a whole. One Member suggested that the strobes should be fitted only over the first 2000 ft of the approach, measured from the down wind point, to avoid the possibility of dazzle over the last 1000 ft., i.e. from a height of approximately 75—100 ft (on a 1 : 20 instrument approach slope). A further advantage would be the added emphasis to the 1000 ft point from threshold, a point which applies equally if adopted on the ALPA System, as the Decision Bar would then also lie at the termination of the strobe lights. The ALPA supporters considered that the addition of cross bars would improve distance indication, and provide better attitude and roll guidance on the down-wind 2000 ft.

Strobe (condenser discharge) lights were considered the principal aid to the identification of airports surrounded by the lights of large cities, as is commonly the case. The main weight of opinion deemed the Calvert System to be the one providing the best means of alignment with the runway (with the proviso that a strobe centre-line should be added); on the other hand it was considered that the ALPA system, by virtue of its multiplicity of barettes and strobes, more readily indicated any deviation in azimuth *after* initial alignment. Calvert was also held best in distance indication and roll guidance.

Threshold indication varied in configuration and colour in each of the three systems. The Calvert system, using green lights and usually with a split threshold i.e. a gap of 60—75 ft symmetrical about the runway centre line, was preferred in this respect too.

The next question, whilst recognising that no system offers adequate height indication, invited opinions on the three systems in question, and the majority declared a preference for the Calvert method, which employs the "raised" effect and convergency of crossed bars. The British RAE two colour code visual guide path indicator, adopted some time ago by the British Ministry of Aviation and recently by the United States FAA, has materially offset the inability of any approach system to give better height indication.

Finally, answers to the "approach lighting" part of the questionnaire were almost unanimous in desiring light intensity to be variable at the captain's request.

Runway lighting

The first question in this part of the questionnaire asked where the narrow gauge lighting should start. The majority favoured a start at the threshold, and a small minority at the aiming point.

Opinion was evenly divided between omni-directional (button lights) or flush (directional) light fittings for use in narrow gauge lighting. A 60 ft spacing between rows was generally favoured, but some Associations considered that where centre-line lights for take-off and landing run guidance are fitted, the spacing could be increased to 75 ft. A longitudinal spacing of 200 ft between the rows of lights was generally favoured. A minority voice asked for 100 ft while another proposed 250 ft. Spacing as low as 100 ft will increase the tendency towards "orchard effect" at the same time adding greatly to the cost of the installation. The difference in practice between 200 and 250 ft is virtually undetectable, which favours the greater spacing on the grounds of economy.

Opinion was almost unanimous that centre-line lighting should commence at the runway threshold and extend the entire length of the runway. Centre-line lighting, together with narrow gauge lighting (sometimes referred to as landing mat), would completely eliminate "black-hole" effect.

Summary and Conclusion

As regards the approach system, the Associations desire a single standard, the majority preferring the Calvert System modified by the addition of strobe lighting, and an appreciable minority the ALPA system with the addition of cross bars. As far as runways are concerned, a summary of Members' opinions is that a runway used for night landings* should have not only edge lighting but also flush narrow gauge lighting in parallel rows 60—75 ft apart, set symmetrically about the runway centre-line and spaced longitudinally at 200—250 ft, takeoff and landing run guidance being provided by flush centre-line lighting along the runway's entire length.

The year 1961 opened with a situation in which, after some thirteen years of peacetime civil aviation, no semblance of uniformity in lighting aids existed or indeed had been internationally agreed upon. In so simple a matter as, for example, the colour of the runway threshold lights, some airports have green (the colour recommended by ICAO) and others red, whilst even white is not unknown.

The researchers have researched; the experimenters have experimented. Much useful knowledge has been gained and exchanged internationally to the betterment of the understanding and appreciation of the essential part which lighting aids play in the safety of air navigation by day as well as by night.

IFALPA's recent contribution has shown a narrowing of the differences of opinion in the two main schools of thought to a point where practical steps to draw up a comprehensive set of standards to replace the present material in ICAO, Annex 14 can be taken.

Implementation will for some be expensive and will no doubt take time but, until standards are set up, no move towards the goal of uniformity in lighting aids can even begin. →

*) "Instrument runway" might, with advantage, replace "runway used for night landings," as light guidance is also required by day in certain circumstances, especially poor visibility. In particular cases, the restoration of poor ground texture or permanently poor horizon may make lighting desirable.

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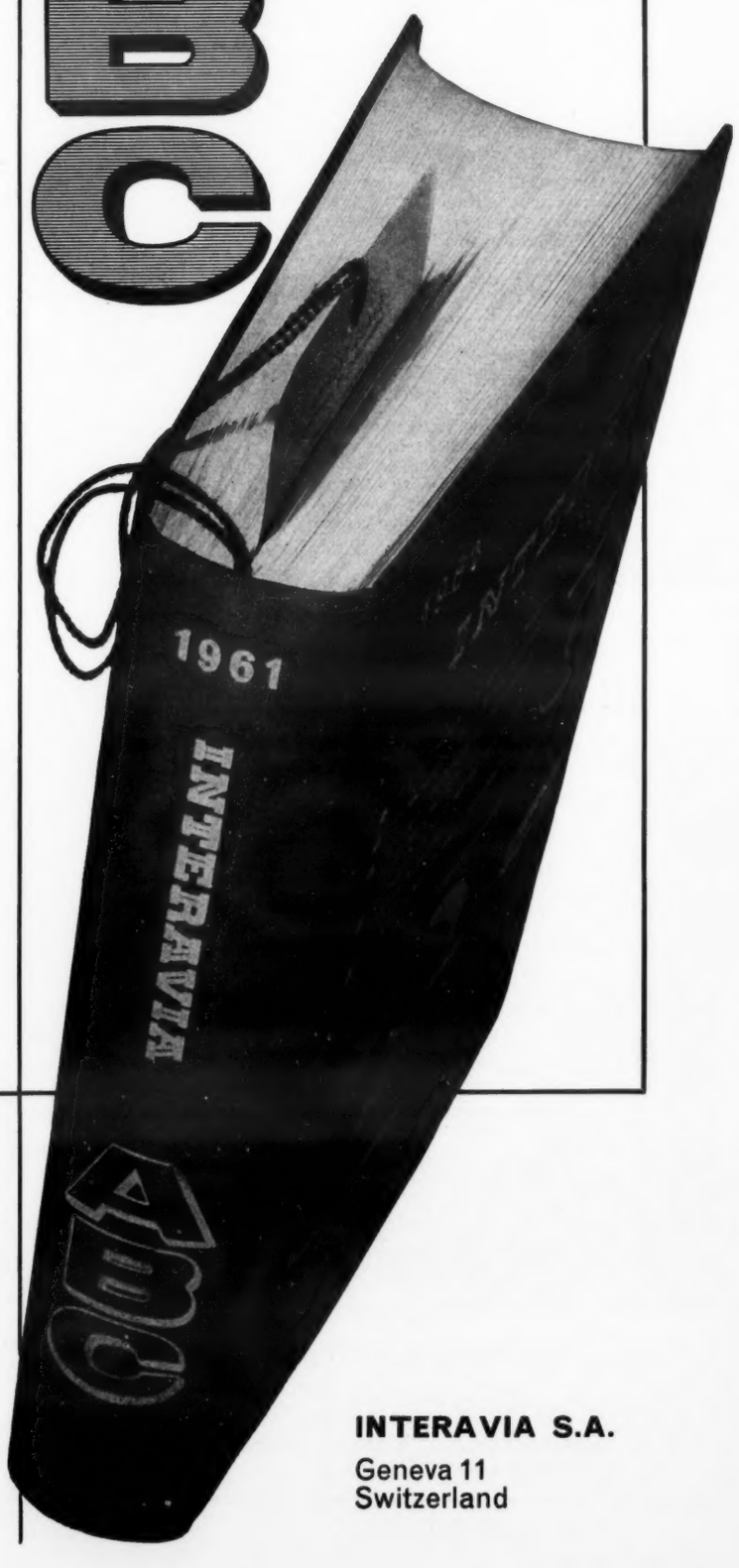

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Book Reviews

Flying Saucers and the U.S. Air Force. — By Lt. Col. Lawrence J. Tacker. — D. Van Nostrand Company, Princeton/London/New York/Toronto, 1960 (English; 200 pages; illustrated; price, clothbound $3.50).

Although this book was published in 1960, it merits discussion, especially during these summer doldrums when the world press blossoms forth with the customary spate of dubious "absolutely reliable" reports of flying saucers darting to and fro about the heavens.

The USAF, which has over the years gathered an impressive array of documentary material on so-called Unidentified Flying Objects (UFO's), has conducted a well-publicized official investigation thereof, whose results have been set forth and discussed with welcome thoroughness by the author, who is Press Officer in the Office of the Secretary of the Air Force. The chapter entitled "It's easy to be fooled" is particularly thought-provoking and entertaining, as it analyses about a dozen "sightings," all of which can be ascribed to mirages, reflections, defective film, or the propensity of uninformed observers to assign an unearthly origin to ordinary, but unfamiliar flying objects. The opinion of the USAF is expressed in measured, but single-minded terms: It does not cast any doubt on the good faith of the observers, but it also discredits the notion that UFO's are manned or controlled by intelligent beings from other worlds, and categorically rejects the possibility that any of the extra-terrestrial objects sighted to date are of this nature. We recommend this book, and hope it will be widely read, as its sound approach should prove most convincing to open-minded readers.

He.

The Modern Airliner — Its Origins and Development. — By Peter W. Brooks; foreword by Sir George Edwards, Executive Director (Aircraft) BAC. Putnam, London, 1961 (English; 176 pages; 38 photographs, 27 tables, 13 graphs and diagrams; price 30/– (board)).

The "credentials" of this well-known writer on aviation are World War II Service in the Royal Navy as an operational and test pilot, a post-war period with the Ministry of Civil Aviation, ten years with BEA as Assistant to the Chief Executive and then to the Chairman, and very recently an appointment with BEAGLE. These give him the necessary experience for recounting the history of the modern airliner in an easily assimilable form, briefly, clearly, and reliably.

In this conscientious work, like all other comparable books on aviation, one misses the noteworthy occurrences between the manuscript and the date of publication; this is of course inevitable, given the rapid pace of development in the industry. Brooks, however, has a talent for outlining future trends carefully and convincingly, so that the "gap" is after all kept to a minimum. The publishers announce that a second volume, entitled "The Worlds' Airliners" is in preparation, and will give detailed information (full technical data, interior layouts, payload/range and operating costs) about the most important aircraft in airline service today. All in all, a useful book.

He.

Dezimalklassifikation — Fachausgabe Elektrotechnik. Second completely revised and enlarged edition. — Published by the Deutschen Normenausschuss (FID-No. 324). — Beuth-Vertrieb GmbH, Berlin/Cologne/Frankfurt, 1960 (German, 135 pages; price DM 26.—; paper-back).

This second German edition of the Universal Decimal Classification, published by the German Standards Institution, is almost half as large again as the 1955 edition and incorporates all the additional terms that have come into force up to January, 1960. In addition to electrotechnical terms, the new edition contains many electronic ones. The fact that some gaps can still be found in the latter is not so much the fault of the publisher but lies mainly in the speedy development of this science, in which new designations and expressions are constantly being coined. This edition treats in great detail the fields of electrotechnics, electricity, magnetism and electromagnetism, nuclear physics, atomic physics, molecular physics, nuclear technology, and nuclear and atomic energy. Moreover, the scientific and technical items important to electrotechnics have been absorbed from all other sections of the Decimal Classification. Numerous applications of electrotechnics such as general machine construction, mining, constructional engineering, the technology of light, telecommunications, metallurgy, precision technology, photography etc. are exhaustively covered. An alphabetical cross-index of 7,000 terms greatly facilitates reference.

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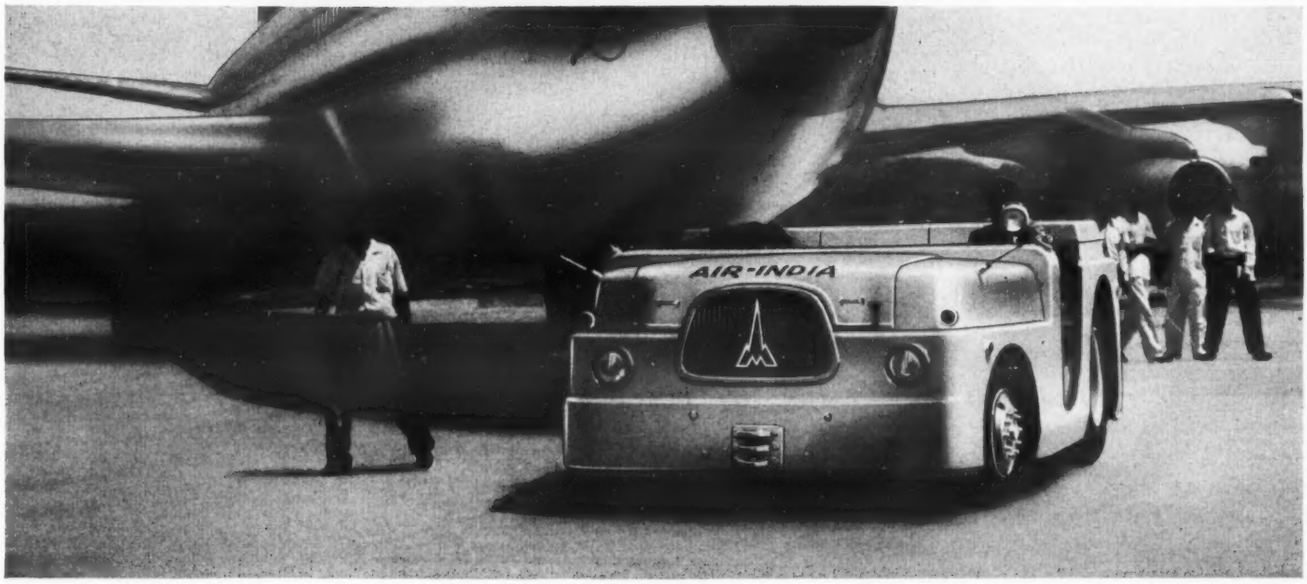

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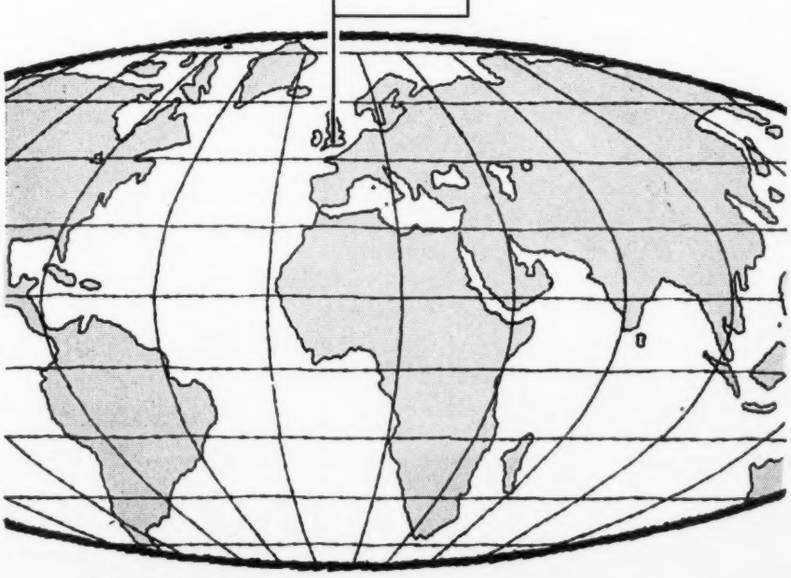

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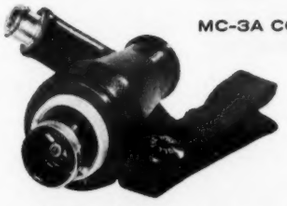

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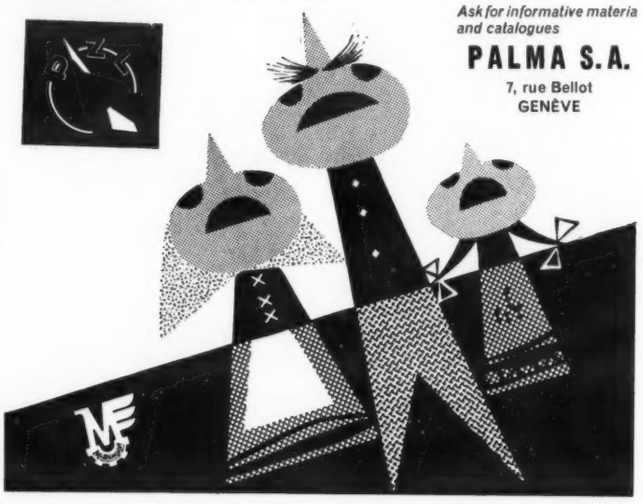

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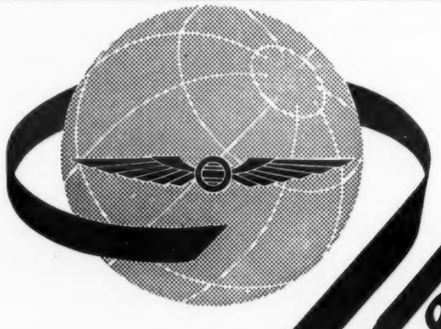

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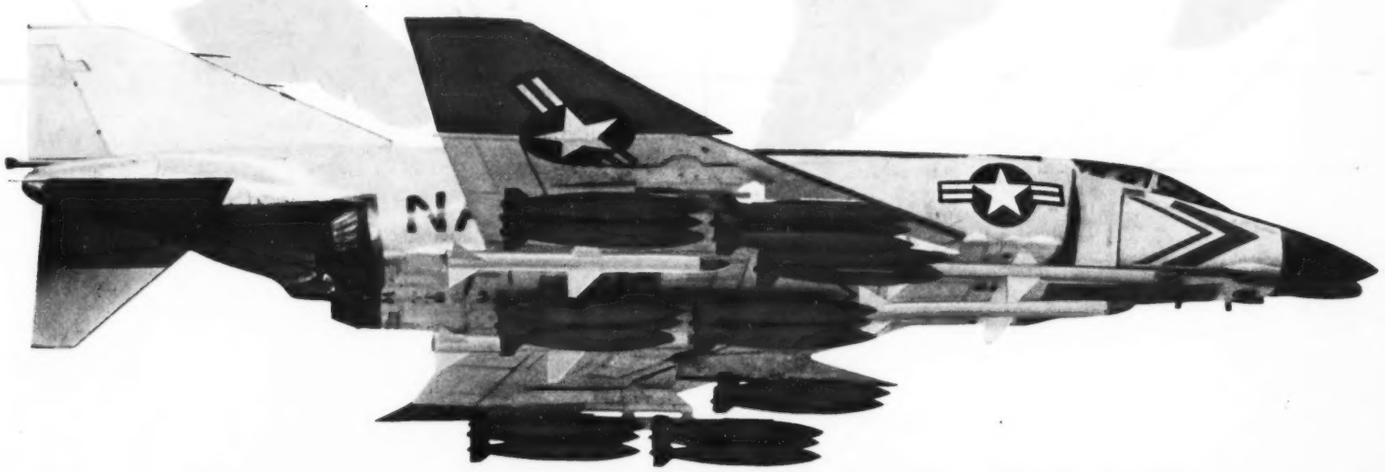

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